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VEGETATION OF PHILIPPINE MOUNTAINS

THE RELATION BETWEEN THE ENVIRONMENT AND PHYSICAL TYPES AT DIFFERENT ALTITUDES

BY

WILLIAM H. BROWN

MANILA
BUREAU OF PRINTING
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PLATE I. A group of tree ferns (Cyathea) in a ravine near the top of Mount Maquiling.

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3. Section of base of *Hydnophytum,* showing cavities inhabited by ants.

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PLATE XXXII

Typical view in the mossy forest near the summit of Mount Maquiling. The conspicuous vines are *Freycinetia*.

VEGETATION OF PHILIPPINE MOUNTAINS

By William H. Brown

INTRODUCTION

The physical characteristics of the vegetation of a given region are largely due to environmental factors, while the phylogenetic relationships depend to a great extent on past or present geographical connections or barriers. In most cases similar external conditions appear to have produced associations of plants whose fundamental physical characteristics are much alike. This fact has made it possible for Warming,* in discussing the vegetation of the world, to formulate an extensive ecological classification based on habitat and physical characteristics rather than on systematic composition. Schimper † likewise divides the vegetation of the world according to habitat.

In preparing the present paper it has been assumed that the distinctly different physical types of climax vegetation on Mount Maquiling and Mount Banahao, Luzon, Philippine Islands, are the result of environment. Working on this assumption an attempt has been made to correlate periodical measurements of environmental factors with the more obvious physical characteristics.

Mount Maquiling is an exceptionally favorable locality for such a study. The advantage of not having to deal with a cold winter season is obvious. From the base to its summit a number of very distinct types of vegetation exist in exceptionally close proximity, so that it is practicable to obtain weekly readings in the more distinct ones. Perhaps of equal importance is the fact that the division of investigation of the Philippine Bureau of Forestry, and the College of Agriculture of the University of the Philippines, are located at the base of the mountain, while the Bureau of Science, at Manila, can be reached by train in about two and a half hours.

The different physical types of vegetation occurring on Mount

* Warming, E., Oecology of Plants. English edition by Groom and Balfour, Clarendon Press, Oxford (1909).

† Schimper, A. F. W., Plant Geography. English edition by Groom and Balfour, Clarendon Press, Oxford (1903).

Maquiling are similar to those natural on many, if not most, mountain peaks rising from the lowlands in moist tropical regions. On the lower slopes there is a lofty evergreen forest, which type Schimper * has shown to be characteristic of moist tropical lowlands. As higher altitudes are reached on Mount Maquiling, shorter trees occur and epiphytes become more numerous, until at an elevation of 1,000 meters there is an elfin forest in which the trees are thickly covered with mosslike plants, interspersed among which are many flowering individuals. This condition is widespread in both hemispheres.

This characteristic gradation from a lofty evergreen forest at low altitudes to a lower mossy one at high elevations, peculiar to mountains in widely separated moist tropical regions, certainly seems to show that the different types of vegetation concerned are due to similar widespread environmental conditions. However, the gradation is not equally characteristic on all mountains and occurs at much lower elevations on some than on others, depending on the geography of the mountain and the region. On Mount Pauai, in the great mountain mass of central Luzon, the mossy forest at an elevation of almost 2,500 meters is taller than that on Mount Maquiling at 1,000 meters; while the isolated cone of Mount Banahao, though more than twice as high as Maquiling, is not so characteristically mossy anywhere on its northern side (the only one the writer has visited) as is the top of Maquiling. For comparison with Mount Maquiling a short description of the vegetation and environment on Mount Banahao is included in the present paper.

Whitford † has given a very comprehensive floristic analysis of the vegetation at different elevations on Mount Mariveles, including the number of individuals of each species on extensive areas. The specific composition of the flora of Mariveles and of Maquiling is very different, but many of the general principles brought out by Whitford will apply not only to Maquiling but also to a large part of the Philippines. For this reason it has not been considered necessary to make a similar study of Maquiling. The vegetation will, therefore, be treated with special attention to measurements of individuals, and in a manner suited primarily to the particular purposes of the present paper. A general discussion will be given of the formations occurring at different levels, with detailed descriptions of limited

* Schimper, A. F. W., Plant Geography. English edition by Groom and Balfour, Clarendon Press, Oxford (1903).

† Whitford, H. N., The vegetation of the Lamao forest reserve, *Phil. Journ. Sci.* (1906), 1, 373.

areas in which the trees of each species have been counted and the chief measurements of all individuals taken. These measurements will serve as a basis for tables by means of which the physical characteristics of the different formations may be compared and studied in connection with the measurements of the environmental factors.

The discussion of the vegetation of Mount Maquiling will be confined to that on the eastern slope.

A list of the species considered, together with the authorities and native names, is given at the end of this publication.

The writer wishes to express his thanks to Dr. F. W. Foxworthy and Mr. D. M. Matthews for facilities afforded him at the division of investigation, Bureau of Forestry, at Los Baños; and to Mr. E. D. Merrill, of the Bureau of Science, for assistance in the identification of specimens.

MOUNT MAQUILING

Mount Maquiling is an isolated volcanic cone situated on Luzon, midway between the eastern and western coasts, about 64 kilometers southeast of Manila, in latitude 14° 8′ north and longitude 121° 11′ east of Greenwich. Its geology has been discussed at some length by Abella.* Its main volcanic activity has been long extinct, though still evident in many hot springs and fumaroles; these, however, do not affect the vegetation, except locally. The position of the crater is not very perceptible, but its rim may be traced in a series of individual peaks, while the streams rising in the center have worn deep and wide channels that have obliterated the central depression. Ashes and lava have disappeared; and the whole mountain, except on very steep slopes, is covered by a deep layer of soil. The vegetation, where not disturbed by man, is apparently a climax type.

Most of the observations recorded in this paper were made on the eastern slope. On this side the ascent of the lower slopes is gradual, while near the top it is, for the greater part, much steeper. This change is more or less gradual but is most pronounced at an altitude of about 750 meters. Plate II, fig. 1, shows this side of the mountain as seen from the College of Agriculture grounds. Plate II, fig. 2, is a view of the opposite side, from Santo Tomas. The topography of the mountain is shown by the map on Plate XLI. The topography of the lower slopes may be described as a series of broad, radiating, well-drained ridges separated by narrow valleys. Above 750 meters there

* Abella y Casariego, D. E., El Monte Maquiling. Madrid (1885).

are flat places, and others with gradual slopes, but at these higher elevations the slopes are usually fairly steep. On the eastern side Mount Maquiling grades into the surrounding plain at an altitude of about 50 meters, while the plain on the opposite side is about 200 meters higher. The mountain is comparatively low, the highest peak reaching an elevation of about 1,140 meters.

The climate of Maquiling and the surrounding country is distinctly monsoon in character. On reaching the eastern coast the northeastern monsoon, coming from the Pacific, strikes a high plateau, which is the divide between Laguna de Bay and the Pacific Ocean. This plateau reaches elevations of from 500 to 600 meters or more, and on it is deposited a large part of the moisture carried by the northeastern monsoon. After passing over this plateau the monsoon reaches Maquiling as a drying wind and produces a very distinct dry season, which is most pronounced about March or April. This dry season is naturally less severe on the eastern than on the western side of Maquiling. At high elevations conditions are comparatively moist at all times. The heaviest rainfall usually occurs between July and September, during the season of cyclonic disturbances (typhoons).

During the rainy season small springs occur high up on the mountain; but, for the most part, the permanent streams rise at elevations around 500 meters. It is very common in volcanic mountains in this region for the water to run underground to such an extent that even on high mountains there are no permanent streams much above the base.

ENVIRONMENTAL CONDITIONS

As an understanding of the vegetation is dependent to a considerable extent upon a knowledge of the environment, it seems advisable to present here a brief summary of the environmental conditions obtaining on Mount Maquiling.

The relative humidity in most parts of the Philippines is comparatively high at all seasons of the year, and this is true of the region in which Mount Maquiling is situated, and particularly so of that side of the mountain on which the present study was made. As in the case of all mountains, the air which is forced up from the lower regions becomes cooler and capable of retaining less moisture. The result is that the relative humidity increases as higher elevations are reached, and near the summit the air under the forest is practically saturated the year

round, while the top of the mountain is bathed in clouds during a large part of the time. The hygrometer under the forest recorded 100 per cent saturation for months at a time. This, however, does not mean that the air was completely saturated, as the instrument used was operated by the contraction and expansion of hairs, which when wet by clouds would require some time to dry before the instrument could record a lower humidity.

Around the base of the mountain the wind is steady during the entire dry season, and evaporation at this time is comparatively high. At other seasons it is much lower. With increasing altitudes the velocity of the wind rises, but on account of the greatly increased humidity the rate of evaporation decreases and at the top is extremely low. For weeks at a time a non-rain-absorbing atmometer under the forest showed no signs of evaporation.

Owing to increasing cloudiness near the top, the amount of light received by the vegetation also decreases gradually as high elevations are reached.

The decrease in evaporation and increase in relative humidity would appear to be fairly independent of the amount of rainfall, as the greatest rainfall occurs at middle altitudes, while the rainfall at the top and at about 300 meters' elevation is practically the same.

The amount of moisture in the soil is always high in the virgin forest but increases at higher elevations, although owing to the contour of the ground the soil appears to be well drained throughout.

The temperature gradually decreases with increasing altitudes, but the range at any given elevation is small.

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PARANG VEGETATION

The Tagalog word parang is a name applied to a mixture of grassland and second-growth forest. Parang is found around the base of Mount Maquiling. The grasses in the parang are usually coarse and from 1 to 3 meters in height. The forest occurs in patches of varying sizes and consists principally of small trees about 6 to 10 meters high. Scattered individuals of fair-sized trees are also found in the parang. This type of vegetation is very common in the Philippines, as it occurs on land from which the original forest has been removed. For a general discussion of cleared areas see Brown and Matthews.*

With the exception of very limited dry areas, the whole of the Philippines must originally have been covered by trees, as environmental conditions throughout the Archipelago are favorable for forests. Both cultivated areas and grasslands quickly return to forest if not disturbed by man and fires are excluded. When land is cleared of forest and cultivated by primitive methods, grasses and other weeds make their appearance. These are frequently removed by burning, especially during the dry season. Fires kill most of the dicotyledonous plants, but do little harm to the rhizomes of the grasses. The result of several successive fires is to leave the land in possession of the grasses, especially *Imperata exaltata* (cogon) and *Saccharum spontaneum* (talahib). After this, cultivation is usually abandoned. Plate III, fig. 2, shows a stand of *Saccharum spontaneum.*

Dead leaves accumulate quickly in stands of *Imperata* or *Saccharum,* so that these grasses become very inflammable during the dry season. At such times a grass area is usually burned over completely, sometimes by accident, but as a rule, intentionally. Burning is resorted to for various purposes; as, for example, to make hunting less difficult, to obtain young growth for forage, or to clear the land so that it can be easily traversed or so that a part of it can be cultivated. When an area is burned over regularly, the grasses form almost pure stands. With primitive methods of agriculture the grasses get a good start even without fires, as their rhizomes are much harder to eradicate than are dicotyledonous plants; but it is only when other plants are destroyed by fire that the grasses form extensive pure

* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests. *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

stands. If the grass is not burned, it is quickly invaded by second-growth trees. If no fire has occurred in an area for two or three years, small patches of trees may appear; but an area is rarely kept free from fire for a period sufficiently long to allow trees to cover it. The part left in grass is usually burned over with fair regularity. The fires may kill the trees at the edge of the forest, or the occasional absence of fires may cause the trees to encroach upon the grass. Thus the parang persists for years, the trees at times gaining and at other times losing ground. When they form a continuous forest, the land is frequently cleared again and cultivated, as such areas are much more easily put under cultivation than is grassland.

When ground is cultivated intensively, or with modern methods, the grasses do not take possession of it; but the shifting system of cultivation just described has been so widespread in the Philippines that, according to Whitford,* 40 per cent of the land area of the Archipelago is occupied by grass, $16\frac{2}{3}$ per cent by second-growth forest, while only 10 per cent is cultivated.

PARANG ON MOUNT MAQUILING

The measurements, recorded in this paper, of environmental factors for the cleared region at the base of Mount Maquiling were made in the limited area between the College of Agriculture and the lower edge of the forest. This area is typical parang. In 1909, when the college was established, most of this land was covered by grasses, chiefly *Imperata exaltata* (cogon) and *Saccharum spontaneum* (talahib).

The original vegetation of the country surrounding Mount Maquiling and most of that on the mountain at elevations below 100 meters has been cleared away and the land put under cultivation. Above this and up to an altitude of 200 meters the forest has been so heavily logged that the main canopy has been removed almost completely and replaced largely by other species. From what is left in ravines and the seedlings found in them and in the forest at elevations between 100 and 200 meters, as well as by a comparison with the forest at higher elevations and other forests occurring in similar situations, we can form some idea of the composition of the original forest of the plain and slopes up to 200 meters. All these conditions would seem to indicate quite clearly that it was, like that now occurring at the next higher elevations, of a dipterocarp type. A diptero-

* Whitford, H. N., The Forests of the Philippines, *Bull. P. I. Bur. For.* (1911), No. 10.

carp forest is one in which the main story is dominated by members of the family Dipterocarpaceae.

The number of seedlings at elevations between 100 and 200 meters and of small trees in the ravines at lower elevations is sufficient to indicate that the main canopy of the original dipterocarp forest, now removed, consisted largely of *Parashorea malaanonan* (*plicata*) (bagtican lauan), *Shorea guiso* (guijo), and *Pentacme contorta* (white lauan). These are all large trees and in this favorable locality probably formed a canopy about 40 meters high. Under this main story there must have been two other stories besides the undergrowth, the whole forming a tall, dense forest. When the area below 100 meters was cleared and for how long a period it was cultivated are uncertain.

The two grasses most prominent in the Maquiling area, *Imperata exaltata* (cogon) and *Saccharum spontaneum* (talahib), have different characteristics and are suited to different habitats. *Imperata exaltata* is the shorter, rarely reaching a height of more than 1.5 meters. The erect stems grow from rhizomes and are spread over the ground rather evenly, with little tendency to form clumps. *Imperata* appears to be disseminated more quickly than *Saccharum* and at first occupied the larger part of the grass area at the base of Mount Maquiling. *Saccharum spontaneum* is taller, being frequently more than 3 meters high, and forms dense clumps. It succeeds *Imperata* in the more favorable localities, while the latter persists in the drier places. *Imperata* will frequently be found on the top of a small hill where the soil is shallow and comparatively dry, while the slopes with deeper and moister soil will be covered with *Saccharum*. Most of the land under discussion is suitable for *Saccharum*, and this is now the more prominent species.

The large grass areas in the Philippines are called cogonales. All these areas appear to have a similar origin and possess many characteristics in common. The species of grasses first entering a cleared area depends to a considerable extent on the proximity of seed-bearing plants; but, as the grass areas become older, the distribution of many of the species will be definitely determined by their habitats, as has been shown in the case of *Imperata exaltata* (cogon) and *Saccharum spontaneum* (talahib), and this distribution will apparently be permanent so long as the area remains in grass. In old grass areas these

two grasses do not form mixtures, but each in its special habitat forms a practically pure stand.

In the grass areas there are usually individuals of a few species other than grasses that, owing to large underground structures, can withstand fire. In the region under consideration the orchid *Eulophia exaltata* is one of the most widespread, while *Blumea balsamifera* (sambong), a shrub, occurs in scattered patches. The fire-resisting trees *Antidesma ghaesembilla* (binayuyu), *Bauhinia malabarica* (alibangbang), and *Acacia farnesiana* (aroma) occur as scattered individuals. When these trees are young their shoots may be killed by fire, but new ones readily spring up from the roots. As each succeeding shoot is usually taller than the one preceding it, the trees finally grow higher than the grass and, in the immediate neighborhood, kill the latter by shading it. In this way the tree may gradually become the center from which a small clump is formed.

Besides the plants just mentioned, a small *Selaginella, S. belangeri,* and a species of *Riccia* were also common in the Maquiling area during the wet season.

When fires are excluded from a grass area, it is invaded by a large number of shrubs, vines, and small trees. The grasses can stand but little shading and soon succumb, and in a few years they are replaced by a second-growth forest of small, rapidly growing trees.

Before the establishment of the College of Agriculture, in 1909, the area between it and the forest appears to have been burned over regularly, and large parts of it were burned as late as 1911; since then fires have been excluded.

Table I shows the composition of a plot 2 meters square in an area of *Imperata exaltata* in 1912.

TABLE I.—*Composition of plot of Imperata exaltata. Plot, 2 meters square.*

IMPERATA EXALTATA (COGON). HEIGHT, 130 TO 140 CENTIMETERS.

Plants with—	
One stalk	1,675
Two stalks	147
Three stalks	82
Four stalks	38
Five stalks	19
Six stalks	15
Total plants	1,976
Total stalks	2,552

MISCELLANEOUS SPECIES.

Species.	Plants.	Greatest height.	Average height.	Seedlings.
		cm.	*cm.*	
Herbs and shrubs:				
Eulophia exaltata	5	60	35	1
Biophytum sensitivum	7	4	3	2
Selaginella belangeri	16	3	2	
Mimosa pudica	68	18	1.5	43
Desmodium pulchellum	122	27	21	84
Commelina nudiflora	7	4.5	3	7
Compositæ	23	6	4	23
Synedrella nodiflora	10	21	8	8
Sida javensis	1	5.5	5.5	1
Riccia sp	many			
Vines:				
Streptocaulon baumii	2	6	5.5	2
Operculina turpethum	1	9	9	
Merremia umbellata	2	280	145	1
Merremia hastata	5	6	3	5
Cissus trifolia	2	173	60	
Ipomoea triloba	9	69	31	4
Total	280			181

An analysis of this plot shows a dense stand of *Imperata.* With the exception of *Imperata* and five individuals of *Eulophia,* which is fire-resistant, all the plants are small, the majority being seedlings. All have invaded the area since the last fire. *Mimosa pudica,* which grows about as tall as *Imperata,* and *Desmodium pulchellum,* which is slightly taller, together with a few other shrubs, are frequently conspicuous in grass areas. Table I shows that the two just mentioned are present in sufficient numbers to insure their prominence, unless killed by fire. *Biophytum sensitivum, Eulophia exaltata,* and *Commelina nudiflora* are small plants and will remain inconspicuous; while *Synedrella nodiflora* is an annual, and *Sida javensis* is a small shrub. Owing to their length some of the vines will soon grow over the grass and become prominent. This invasion of an *Imperata* area by small shrubs and vines is typical. They grow along with the grass, and while making the stand of grass less dense they do not usually drive it out. This is done, however, by trees that enter an area very quickly after fires are excluded. The change from almost pure stands of grass to the first stages of invasion by trees is usually accompanied by a change in the composition of the grasses, *Imperata exaltata* and *Saccharum spontaneum* being replaced by species forming taller but less-dense stands.

The tree species may invade either the relatively pure stands of grass or those mixed with shrubs and vines. The invading species are numerous, but most of them are alike in their chief characteristics. They are usually small, 10 meters or less in height, and are intolerant species with soft wood. They grow rapidly, mature early, and decay quickly. There are some exceptions; as, for example, *Bischofia javanica* (tuai), a large tree occasionally found in parang, and *Psidium guajava* (guava), a small tree which has fairly hard wood. As the trees grow up in the grass they shade the intolerant grasses, causing them to disappear. The trees thus come to form patches of second growth mixed with the grass.

In the area under discussion the second-growth forest has already occupied much of the ground and, as fires will probably be excluded permanently, it will continue to spread until the grass has disappeared. Judging by the present rate of invasion, this process should be completed in less than ten years.

The first trees to enter the grass were naturally those having pronounced ability to resist fires; namely, *Acacia farnesiana* (aroma), *Antidesma ghaesembilla* (binayuyu), and *Bauhinia malabarica* (alibangbang). As soon as fires were excluded, these were followed by a large number of others. The species are so numerous, and the composition of the forest is so varied, that it is difficult to tell which species are most prominent in forming the young second-growth forest; but among them are *Melochia umbellata* (labayo), *Columbia serratifolia* (anilao), *Litsea glutinosa* (puso puso), *Macaranga tanarius* (binuñga), *Macaranga bicolor* (hamindang), *Premna cumingiana* (maguili), *Ficus nota* (tibig), *Ficus hauili* (hauili), *Ficus ulmifolia* (isis), *Mallotus philippensis* (banato), *Mallotus ricinoides* (hinlaumo), and *Alstonia scholaris* (dita). Some of the other prominent species are *Trema orientalis* (anabion), *Cordia myxa* (anonang), *Canarium villosum* (pagsahing), *Leucaena glauca* (ipil ipil), *Pipturus arborescens* (dalunot), *Voacanga globosa* (bayag-usa), *Leea manillensis*, *Litsea perrottetii* (marang), *Psidium guajava* (guava), *Eugenia cumini* (duhat), *Mallotus moluccanus* (alim), and *Artocarpus cumingiana* (anubing). Plate IV, fig. 1, shows a tree of *Macaranga;* Plate IV, fig. 2, *Ficus nota;* and Plate IV, fig. 3, an old individual of *Trema orientalis.* The second-growth forest contains a great many species besides those mentioned above, some of them being possibly more prominent than a number of those listed.

The plants range in size from small, bushlike forms, such as

Tabernaemontana pandacaqui (pandacaqui) and *Mussaenda philippica* (cahoy dalaga), to large trees, like *Parkia javanica* (*timoriana*) (cupang); the last is occasionally found in both the parang and the dipterocarp forests.

The distribution and the requirements of the different species also vary considerably. *Bischofia javanica* (tuai), a large tree frequently more than a meter in diameter, is represented in the parang by a few individuals and also occurs in the dipterocarp forest and even at elevations above the dipterocarp forest. *Leea manillensis*, a small tree, is very common in the lowest tree story in both the dipterocarp forest and the forest at the next higher elevations; it is also a dominant tree in the parang. *Tabernaemontana pandacaqui* is prominent as an undershrub in the dipterocarp forest and is also a common weed in open ground. On the other hand *Trema orientalis* (anabion), a very rapidly growing species, is extremely intolerant of shade. It produces large numbers of small seeds, which are quickly and thoroughly scattered by birds. Where the ground has been cleared, as by logging, it frequently forms almost pure stands of great extent.* On Maquiling it has taken possession of several clearings. The writer made a clearing in the forest of Mount Maquiling at an elevation of 450 meters. *Trema* invaded this so quickly and in such large numbers that it soon formed an almost pure stand. This is the more remarkable as the nearest seed plants observed were at a considerable distance and about 200 meters lower in elevation. The seeds of *Trema* are certainly well distributed; and, if conditions are favorable, they come up in large numbers. *Trema* does not, however, come up under other trees, and is not so successful as are many others in invading grassland. It seems not improbable that it usually gets its start in grass when the latter has been temporarily disturbed by some external agency.

Since the trees forming the second-growth forest have such decidedly different characteristics, it would seem that it ought to be easy to subdivide it into smaller ecological units. Such, however, is not the case. The larger trees play an inconspicuous part in the early stages. The others form a heterogeneous mixture in which certain ones are more prominent in some spots, while others are more numerous elsewhere without there being any very apparent reason.

The successions on cleared areas that are not cultivated are much less complex than in grassland. In northern Negros *Tre-*

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* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests. *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

ma orientalis invades clearings and forms extensive, almost pure stands, which can be measured in square kilometers and are only limited in extent by the size of the clearings.* Likewise, there are places where, under different conditions, other second-growth trees form almost pure stands on cleared land. Another striking example is the extensive area covered by *Homalanthus populneus* (balanti) on Mount Mariveles.†

The succession on grasslands is usually very complex, and such a mixture as we find at the base of Maquiling is the rule rather than an exception. In the area under discussion there are certainly no clearly defined subdivisions, and for the present it is probably best to regard the forest as a single type and to apply to it Whitford's term "second-growth forest."‡

The individual species in this forest play different roles: as, for example, the fire-resisting ones are the first invaders; *Trema* enters only in the early stages and has a very open crown; tolerant species close the canopy; *Macaranga* enters early, grows rapidly, and at the same time casts a fairly dense shade. Each species thus has its individual peculiarities, which fact, together with the favorable conditions of a tropical climate, probably accounts for the great diversity of the forest.

Besides the trees there are many minor species, including small grasses and other herbs, shrubs, and vines. The composition varies very greatly in different localities and is influenced particularly by the density and age of the forest. The undergrowth is frequently dense, while vines are numerous. In the earlier stages the most prominent vines are members of the family Convolvulaceae.

The forest may perhaps be best described as one in which a great variety of small trees, shrubs, and vines are grouped together in a dense, heterogeneous tangle.

The canopy of a second-growth forest is much less dense than that of a dipterocarp forest, and the conditions within the forest are much drier. This is especially true of young forests like the one on Maquiling. The undergrowth is, therefore, usually somewhat xerophytic. Epiphytes, other than small crustaceous lichens, are practically absent from the parang.

The second-growth forest will naturally pass over into the

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* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), **9**, 451.

† Loc. cit.

‡ Whitford, H. N., The Forests of the Philippines, *Bull. P. I. Bur. For.* (1911), **No. 10**.

dipterocarp type; but, as this process can hardly be said to have begun, it is impossible to describe the successions. It has already been shown that some species are common to both the second-growth and the dipterocarp forests. As the second growth becomes older, other species from the dipterocarp forest will invade it, and the vegetation will become taller and denser, until finally conditions will be moist enough for the dipterocarps themselves to enter. At present there are on the edges of ravines a few large individuals of *Parashorea malaanonan* (bagtican lauan), which have been left from the original forest. These scatter large quantities of seed over the parang; but, as they do not produce seedlings, it is evident that conditions are not yet favorable for *Parashorea.*

The above description of the parang at the base of Mount Maquiling, between the College of Agriculture and the dipterocarp forest, applies to conditions as they were observed from 1912 to 1915. Since that time they have been very materially altered by cultivation.

No measurements of the stand were made in the second-growth forest, as its composition is so varied and it changes so greatly with age that it was not considered practical to obtain representative plots.

DIPTEROCARP FOREST

Forests of the dipterocarp type are characteristic of situations favorable for plant growth in the lowlands of the Philippines, and according to Whitford * they cover 75 per cent of the virgin forest area and contain 95 per cent of the standing timber of the Archipelago. For an extensive account of Philippine dipterocarp forests see Brown and Matthews.†

The dipterocarp forest on Mount Maquiling begins at the upper edge of the parang and extends up the slopes of the mountain to an elevation of about 600 meters. This forest is located in the center of a well-populated district and has been subjected to a process of selective logging for many years; naturally, the more accessible portions have been most heavily logged. The cutting has been so severe at elevations below 200 meters that the forest has largely lost its dipterocarp character. Between 200 and 400 meters' elevation there has been less logging; and, although the trees most valuable for commercial purposes have been largely removed, the general character of the forest has probably not been greatly changed at elevations above 300 meters. Above 400 meters logging has not been carried on extensively.

In describing this forest it will be convenient to divide it into a cut-over type and a natural one, and to make the 300-meter contour the line of separation; this division is, of course, arbitrary. The upper and lower portions differ, however, not only in the extent to which they have been logged, but also probably in original composition.

The dominant dipterocarps of this forest are *Parashorea malaanonan* (*plicata*) (bagtican lauan), *Shorea guiso* (guijo), and *Pentacme contorta* (white lauan). The last mentioned two are very valuable timber trees, while *Parashorea* is much less highly prized and is far more prominent over the whole area than are the other two.

A study of the present distribution of seedlings and saplings of the dipterocarps throws much light on their past distribution.

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* Whitford, H. N., The Forests of the Philippines, *Bull. P. I. Bur. For.* (1911), No. 10.

† Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

In the region between 200 and 300 meters' elevation large individuals of *Shorea guiso* and *Pentacme contorta* have been almost entirely removed, but there are present large numbers of seedlings and saplings of these species. This would indicate that *Shorea* and *Pentacme* were fomerly prominent in the area. *Parashorea* has been removed to only a slight extent at elevations above 200 meters and probably not at all above 250 meters. A comparison between the ratio of small to large trees of this species and similar ratios of *Shorea* and *Pentacme* will, therefore, indicate the extent to which the last two have been removed at higher elevations. Such a comparison does not show that *Pentacme* has been removed at all at elevations of about 300 meters, while the large specimens of *Shorea* in the same region have for the most part disappeared. Here there are perhaps eight small individuals of *Parashorea* to one of *Shorea*. At an elevation of about 450 meters *Shorea* has apparently not been removed to any considerable extent. At elevations above 300 meters there are many times as many individuals of *Parashorea* as of *Pentacme*, although the latter does not appear to have been logged at this elevation and there have probably always been seven or eight of *Parashorea* to one of *Shorea*. This would indicate that in the virgin condition of this area *Parashorea* was dominant and that, as stated above, the dipterocarp character of the forest above the 300-meter contour has not been greatly changed.

It is not practicable for one man to obtain exact figures in dealing with the composition of so large and dense an area as this dipterocarp forest. The figures given here are, however, probably correct in the main, for they include numerous observations over a long period and are confirmed in a number of cases by extensive measurements taken by Dr. F. W. Foxworthy and his class in dendrology—particularly by a classification made by them in 1915 of all individuals of tree species on one square kilometer. We can only guess at the ratio that formerly existed on the lower slopes, but *Shorea* and *Pentacme* were probably much more prominent there than at altitudes above 300 meters.

The dipterocarps are by no means the only species that have been cut, as there are many others, such as *Koodersiodendron pinnatum* (amugis), *Strombosia philippinensis* (tamayuan), and *Dillenia philippinensis* (catmon), that are valuable. These, however, like the dipterocarps, have been removed to a much greater extent at lower than at higher elevations.

Environmental conditions in the forest have probably not

undergone marked change above the 300-meter contour. One important reason for this is that the forest consists of a mixture of a great many species, many of which are not valuable for local use. This is true of *Parashorea malaanonan* and *Celtis philippensis* (malaicmo), the two trees that are far more numerous than any others in the dominant story, and also of *Diplodiscus paniculatus* (balobo), a second-story tree, represented by about three times as many individuals as any other except the two just mentioned.

Cutting may change the value of the stand considerably, even though it may not affect the environment within the forest. When the valuable trees are cut their places are naturally taken by others, and as growth within the forest is slow much time may elapse before the valuable species occur again as large individuals. Many of the trees form soft and medium-hard woods valuable in temperate countries for construction timbers; but these are quickly destroyed by termites and fungi in the Philippines and, therefore, are not sought by loggers who, like those who have worked on Maquiling, use animals to haul their lumber. Other trees have wood that is very hard to work. For these reasons trees that would be used by a sawmill have been left even on the lower slopes of Maquiling. Brown and Matthews * have given a short description of this forest and discussed the forestry problems connected with it.

Not only has the forest above the 300-meter contour undergone comparatively little change so far as environment is concerned, but the number of individuals of each species has also been changed much less than might be supposed. Each species is usually represented by more small individuals than large ones; and, as only a portion of the latter have been removed, a count of those present gives a fairly good idea of the original composition. From the standpoint of the present paper we would appear to be justified in treating the forest above an elevation of 300 meters as a natural climax one. However, the plot used for detailed measurements was located at an elevation of about 450 meters and in an area where there has been little logging. There was no evidence of trees having been removed from the plot.

For convenience the more nearly virgin forest (that above the 300-meter contour) will be discussed first, as the cut-over forest will then be more easily understood.

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* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

VIRGIN DIPTEROCARP FOREST

The virgin dipterocarp forest, which we have considered as extending from the 300-meter contour to an elevation of approximately 600 meters, is decidedly a lowland, moist-tropical forest formation. In the Philippines dipterocarp forests are characteristic of the moist plains and lower slopes of mountains, giving way to other types in drier situations, and usually at an altitude of 800 meters or less. From the standpoint of the physical characteristics of the vegetation the dipterocarp forest on Maquiling is a lofty, evergreen, three-storied forest formation.

The regular occurrence of lofty, evergreen forest in lowland, moist-tropical regions would certainly seem to justify the use of the term lowland, moist-tropical forest formation.

The dipterocarp forest of Maquiling not only represents a single formation, but except for the tension zone at its upper limits also belongs to a single well-defined association, which from its composition should be called the *Parashorea-Diplodiscus* association. This forest, like the dipterocarp types described by Whitford * from Mount Mariveles, contains a great mixture of species. There are probably at least three hundred fifty tree species in the dipterocarp forest of Mount Maquiling.

Some species are more prominent at lower than at higher altitudes, while with others the reverse is the case. Again, certain species will be more numerous in limited areas than elsewhere, or species that occur in fairly large numbers in one locality may not be represented in a neighboring one. The reasons for some of these differences are more or less obvious; as, for example, certain species do best in the valleys and others on the ridges. In general, however, the composition is fairly uniform, the slight differences being confined largely to the less conspicuous elements of the vegetation.

The development of the trees varies somewhat according to the topography. Large trees are scarce in ravines and narrow valleys, while on the tops of sharp ridges the individuals may have large diameters but are usually shorter than on gentle slopes. In ravines the light is poor, while on sharp ridges the trees do not have to grow particularly tall to enable them to reach the light. Therefore, it would seem that light is the factor determining their development. In ravines the undergrowth also is more open than on the ridges. The small size of the trees in a ravine is shown in Plate VIII, fig. 2.

* Whitford, H. N., The vegetation of the Lamao forest reserve, *Phil. Journ. Sci.* (1906), 1, 373.

The trees are arranged in three rather definite stories. The first, or dominant, story forms a complete canopy; under this there is another story of large trees, which also forms a complete canopy. Still lower there is a story of small scattered trees.

Plate V is a view in the virgin dipterocarp forest at an altitude of about 500 meters. The large tree in the center is a *Parashorea malaanonan.* On the right are two second-story trees, while in the center at the left a third-story tree can be seen very plainly. Plate VI, fig. 1, is another view at about the same altitude. A view of this forest at the edge of a recent clearing is shown in Plate VII. In making the clearing several specimens of the palm *Livistona* sp. were left standing; these are seen in the foreground.

FIRST, OR DOMINANT, STORY

The Maquiling region has a too pronounced dry season for the best development of a dipterocarp forest; and, moreover, this type is usually much poorer near its upper limits than at lower elevations. It is not surprising, therefore, that the first, or dominant, story is not so well developed nor so distinctly dipterocarp as is that of forests in more favorable situations. The first story is irregular and, while usually continuous, is not very dense.

The most prominent tree is *Parashorea malaanonan* (bagtican lauan), which reaches a height of 35 to 40 meters and is frequently considerably more than a meter in diameter. Over large areas there are more than twice as many individuals of this species having a diameter of a meter or more as of all other species together. This does not take into account the strangling figs with their irregular and hollow trunks; these occur in the proportion of one large individual of *Ficus* to about three of *Parashorea*. *Parashorea,* like the other dominant dipterocarps, is taller than most trees of the first story. Its crown is flat and spreading and has a tendency to grow out over the neighboring trees. Other species, such as *Canarium luzonicum* (pili) or *Eugenia* spp., are represented by large individuals that, like *Parashorea,* tower over the surrounding trees; however, they seldom dominate their surroundings as do the dipterocarps.

Celtis philippensis (malaicmo) is a good example of another class of trees in the first story. It is represented by probably about two-thirds as many individuals as *Parashorea,* and next to it is decidedly the most numerous tree in the first story. It is a smaller and shorter tree than *Parashorea;* and, while it

may reach the upper surface of the canopy, it is usually somewhat shaded by taller individuals like *Parashorea*. *Celtis philippensis* is one of the species that are more numerous at lower than at higher altitudes. Among the more prominent of the remaining species are *Shorea guiso* and members of the genera *Eugenia*, *Canarium*, and *Palaquium*.

Under the first story there are two other stories, each composed of different species, and a ground covering. The presence of the three stories of different trees is not evident on casual observation, for the composition of all the stories is very complex and few of the trees present any striking peculiarities, while smaller trees of a higher story always occur in a lower story and between the different stories.

SECOND STORY

The second, or middle, story is composed of fair-sized trees, which spread their leaves under the branches of those of the top story. The trees of this story, like those of the first, vary greatly in height. There is, of course, no sharp line separating the different stories; but the second story may be regarded as having an average height of about 18 meters, although many individuals will grow as tall as 20 meters or even taller. Occasionally, under favorable circumstances, a tree of the second story may make exceptional growth and take a place in the dominant canopy; but usually they remain under the first story, except in cases where, by the falling of an old tree, they are temporarily exposed to full sunlight. Most of the second-story species grow to more than 50 centimeters in diameter, and some of them attain diameters of a meter or more. In this story there are many individuals with diameters of from 50 to 80 centimeters.

The second-story trees have much smaller crowns than do those of the dominant story, and they are much more numerous than the latter. This story also contains a greater number of species than either the first or the third and probably as many as both.

The most prominent species is *Diplodiscus paniculatus* (balobo), represented by many more trees than any other species in the forest, and probably about four times as numerous as any other second-story species. The next most prominent species are probably *Diospyros ahernii* (anang), *Dillenia philippinensis* (catmon), and *Nephelium mutabile* (bulala). Among the other important ones are *Diospyros discolor* (camagon),

Strombosia philippinensis (tamayuan), and members of the genera *Aglaia* and *Chisocheton.*

THIRD STORY

The third story, like the other two, is composed of species attaining different heights. The average height of this story is probably about 10 meters. Comparatively few of the trees are more than 30 centimeters in diameter, and most of them are much smaller. The foliage is usually not dense, and the crowns are small. There are fewer species than in the second story, and in a given area of forest there will be about half as many individuals of third-story species as there are of second-story ones. This is probably due partly to the situation of this story and partly to competition with smaller individuals of the other stories. There are several times as many trees in the third as in the second story, but most of them are small individuals of the taller stories.

Some of the species are not evenly distributed throughout the area, and the composition of the third story is probably not so uniform at low and high altitudes as is that of the other stories. Among the most prominent and widely distributed are *Thea montana, Garcinia* spp., *Laportea subclausa* (lipa), and *Leea manillensis.*

Whitford,* in discussing the vegetation of the Lamao forest reserve, describes a dipterocarp type which he calls the *Anisoptera-Strombosia* formation, and in which he says a two-story vegetation prevails. This forest has a storied arrangement very similar to that in the *Parashorea-Diplodiscus* association on Mount Maquiling. Whitford evidently includes in the second story or in the undergrowth those plants which in this paper are regarded as forming the third story.

Brown and Matthews † describe the Philippine dipterocarp forest as composed of three stories. Any division into stories is more or less arbitrary; but there are certainly three very distinct classes of trees in the dipterocarp forests, and it is convenient to divide the vegetation into three stories.

Wallace, ‡ in discussing the general character of the forests

* Whitford, H. N., The vegetation of the Lamao forest reserve, *Phil. Journ. Sci.* (1906), 1, 373.

† Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

‡ Wallace, A. R., Natural Selection and Tropical Nature. London (1895), 240–244.

in the equatorial belt, describes them as composed of three stories of trees, as will be seen from the following quotation:

The observer new to the scene would perhaps be first struck by the varied yet symmetrical trunks, which rise up with perfect straightness to a great height without a branch, and which, being placed at a considerable average distance apart, give an impression similar to that produced by the columns of some enormous building. Overhead, at a height, perhaps, of a hundred and fifty feet, is an almost unbroken canopy of foliage formed by the meeting together of these great trees and their interlacing branches; * * *. The great trees we have hitherto been describing form, however, but a portion of the forest. Beneath their lofty canopy there often exists a second forest of moderate-sized trees, whose crowns, perhaps forty or fifty feet high, do not touch the lower-most branches of those above them. * * * Yet beneath this second set of medium-sized forest trees there is often a third undergrowth of small trees, from six to ten feet high, of dwarf palms, of tree-ferns, and of gigantic herbaceous ferns. Yet lower, on the surface of the ground itself, we find much variety.

VINES

Vines are very numerous in the *Parashorea-Diplodiscus* association. These are very evident in Plate V and in Plate VI, fig. 1. The most conspicuous are species of the climbing palms *Calamus* and *Daemonorops* (rattans), which in their early stages are also the most noticeable element in the ground covering. The rattan plant forms a rosette when young, and maintains this form until the spiny, pinnate leaves are 2 to 3 meters long. After this it sends out a climbing stem with long internodes. This scrambles up among the trees, sometimes attaining a length of more than 100 meters. The midribs are armed with strong recurved spines, besides which there is a lashlike structure (in some species an extension of the midrib and in others growing directly from the stem), also covered with recurved spines. These spines enable the plant to climb, while other smaller ones, scattered over the leaves and long leaf-bases, help to protect it from being eaten by animals. These rattans are very numerous, and their feathery leaves are exceedingly prominent in giving character to the appearance of the vegetation. The feathery leaves of the rattan are very conspicuous in the undergrowth in Plate V.

Climbing bamboos, especially *Schizostachyum diffusum,* are very abundant and conspicuous. The leaves of a climbing bamboo are shown at the left of Plate VI, fig. 2. Besides these there are other prominent monocotyledonous vines, particularly members of the families Pandanaceae and Araceae, the genera *Freycinetia* and *Pothos* being very prominent. Large dicotyledonous vines are also numerous, especially on the trunks of

the larger trees. The long spirally arranged leaves of *Freycinetia*, a genus of the Pandanaceae, are crowded together over considerable lengths of stem and make these plants conspicuous, while the dicotyledonous vines are chiefly noticeable, except when in flower, as large cords extending from the ground to the crowns of the trees. A conspicuous development of *Freycinetia* is shown on Plate XXX. *Symphorema luzonicum* appears to be the most numerous of the dicotyledonous vines, possibly because of its showy flowers. The vines, naturally, increase the density of the vegetation.

STRANGLING FIGS

A very striking appearance is presented by the strangling figs, species of *Ficus*. They start as epiphytes in the tops of the trees and send down roots that reach the ground (Plate XIII, fig. 1). Branches from these roots grow around the tree and coalesce either with each other or with the main root, until the trunk of the tree is usually enclosed by a network (Plate XI, fig. 2). As this grows and coalesces, it interferes with the growth of the tree, the fig leaves shade the tree, and the roots of the fig interfere with those of the tree. This combination usually results in the death of the tree on which the fig is growing. The meshlike support of the fig continues to grow until it may finally have the appearance of a solid trunk. Usually, however, some of the meshes persist (Plate XII, fig. 1). The final appearance of these figs is greatly influenced by the form and height of the trees on which they start. When they grow on slanting or peculiarly shaped trees, they sometimes assume very fantastic shapes.

Plate XI, fig. 1, shows a very large strangling fig, which apparently developed on one tree and then sent roots down a neighboring tree. The result is a conspicuous harplike appearance. The large size of the tree can be seen plainly by comparing it with the man in the picture. These strangling figs are very numerous and often give a picturesque appearance to the vegetation. Old individuals are properly considered trees.

MONOCOTYLEDONOUS TREES

Erect palms are very scarce as compared with rattans or dicotyledonous trees, but are present in sufficient numbers to ornament the forest. Their bulk is inconsiderable, and they have almost no influence on the other elements of the vegetation. Their crowns frequently reach into the second story. The most prominent is *Livistona* sp. (anahau), a fan-leaf palm. A large

specimen of this palm is seen in the center of Plate V and a small individual in the lower right. Several large specimens are shown on Plate VII. The other species have pinnate leaves. *Pinanga insignis* and *Caryota cumingii* occur in considerable numbers, *Heterospathe elata* is less numerous, while *Arenga pinnata* (sugar palm) is conspicuous at lower elevations.

Wallace,* in discussing the occurrence of palms in the equatorial belt, says:

> They are, however, by no means generally present, and we may pass through miles of forest without even seeing a palm. In other parts they abound; either forming a lower growth in the lofty forest, or in swamps and on hillsides sometimes rising up above the other trees.

Monocotyledonous trees are also represented in the dipterocarp forest by a few scattered specimens of *Pandanus luzonensis* and *P. gracilis*, which belong to the third story.

BUTTRESSES

In this, as in many other tropical forests, buttresses † and cauliflory are characteristic of a number of species. A considerable proportion of the tall trees have large planklike buttresses, which in extreme cases may extend several meters from the tree and probably help to support it (Plate XII, fig. 2). Whitford ‡ has discussed the occurrence of these in the Lamao forest.

CAULIFLORY

Cauliflory occurs in a number of species, particularly in the genus *Ficus*. This character is not found in the largest species, and the number of individuals possessing it is insignificant when compared wth the total number of trees present.

GROUND COVERING

Rattans in the rosette stage are the most prominent element in giving character to the appearance of the ground covering throughout the forest. The other elements vary according to the locality. Small individuals of tree species are the most numerous plants on the ridges at the lower elevations. In these localities succulent herbs are rare and ferns are represented by very few individuals. In the wet ravines succulent herbs are

* Wallace, A. R., Natural Selection and Tropical Nature. London (1895), 248.

† Schimper, A. F. W., Plant Geography. English edition by Groom and Balfour, Clarendon Press, Oxford (1903).

‡ Whitford, H. N., The vegetation of the Lamao forest reserve, *Phil. Journ. Sci.* (1906), 1, 373.

conspicuous; species of *Elatostema*, small shallow-rooting herbs, are present in large numbers, while ferns are numerous. The latter are usually fairly small species; but *Angiopteris angustifolia*, with fronds from 3 to 5 meters in length, is fairly common and very showy. At the higher elevations, about 500 meters or more, succulent herbs, especially *Elatostema*, are conspicuous and cover large patches of ground even on the ridges. The environment here is moister, and ferns are a very noticeable element in the undergrowth.

Except at high elevations and in spots along the streams, the ground is not carpeted with vegetation. The undergrowth is dense as one looks through the forest, but the soil itself is bare.

EPIPHYTES

Epiphytic vegetation is scarce, being confined chiefly to the large branches of the tallest trees. Here they form veritable aërial gardens. The chief components are ferns (particularly the humus-gathering *Drynaria quercifolia*), orchids, and species of *Hoya*. All of these are pronounced xerophytes and usually have well-developed water-storing tissue. *Drynaria* has large fleshy stems which store water, while certain of the leaves are modified and form cups for collecting humus. These gather soil for the *Drynaria*, but also produce a substratum in which many other plants take root. The epiphytes forming these aërial gardens are in an advantageous situation for collecting water and for making full use of the sunlight.

Mosses and hepatics, on the trunks of the trees, are very rare. Other epiphytes on the trunks or even in the crowns of the small trees are also scarce, and with the exception of *Asplenium nidus* (bird's-nest fern) are for the most part inconspicuous. The bird's-nest fern, on the other hand, with its many entire fronds a meter or more in length, is the most striking epiphyte in the forest. This plant grows either in the crotches of the trees, on the lower branches, or along the trunks. When so situated that its fronds can grow freely, these radiate from the center in all directions, from which habit it derives its name. It does best in the moister situations and is not present on the drier ridges.

The largest epiphytes, other than young strangling figs, are members of the genus *Schefflera*. These are vines with palmately divided xerophytic leaves, and woody stems several centimeters in diameter. They usually start in hollows in the trees, in crotches, or in other places where a quantity of débris has accumulated.

Phalaenopsis amabilis, a handsome orchid, grows high up on the trunks of trees and is collected by orchid hunters, but is rarely seen by anyone else. This is an example of a number of plants, usually less showy, which are small and occur in such limited numbers that they do not influence even the appearance of the vegetation. The Philippine flora is very rich in Orchidaceae, there being about seven hundred fifty species, many more than there are in any other family. Most of these have small inconspicuous flowers, but a number are showy and are highly prized by orchid collectors. However, in the tall forests showy individuals are rare and, as noted above, are usually hidden by the foliage.

Wallace,* in discussing the orchids in the equatorial belt, says:

> Yet notwithstanding the abundance and variety of orchids in the equatorial forests, they seldom produce much effect by their flowers. This is due partly to the very large proportion of the species having quite inconspicuous flowers; and partly to the fact that the flowering season for each kind lasts but a few weeks, while different species flower almost every month in the year. It is also due to the manner of growth of orchids, generally in single plants or clumps, which are seldom large or conspicuous as compared with the great mass of vegetation around them. It is only at long intervals that the traveller meets with anything which recalls the splendour of our orchid-houses and flower shows.

FLOWERS

Showy flowers are not so conspicuous in the *Parashorea-Diplodiscus* association as in deciduous temperate forests. This is not due so much to scarcity of flowers as to a lack of a definite blooming period when the trees are leafless, and to the absence of a ground covering of herbs that in temperate countries have a striking display of flowers in the spring. A very large proportion of the flowers in the dipterocarp forest are in the tops of the tall trees and so are completely hidden by the foliage. The flowers of *Planchonia spectabilis* are large and very handsome, but are only seen as scattered specimens that have fallen to the ground. *Parashorea malaanonan* has yellow flowers tinged with pink, which fall in such numbers as almost to cover the ground under the large flowering trees. These flowers would be very conspicuous if they were borne in like quantity on short leafless trees. The *Parashorea-Diplodiscus* association is, however, like the temperate deciduous forests in that the majority of the trees have small and inconspicuous flowers.

* Wallace, A. R., Natural Selection and Tropical Nature. London (1895), 256.

Showy flowers are not confined to the dominant canopy, as a few of the under-story trees have displays which are readily seen from the ground. *Dillenia philippinensis,* a common second-story tree, has very handsome, large, white flowers, but usually only a few are open at one time. The purple clusters of *Clerodendron quadriloculare,* a third-story species, are pretty but not conspicuous at a distance.

The flowers of most of the vines are produced in the crowns of the tall trees. *Symphorema luzonicum* is very common, and has flowers with large lilac-colored bracts. These are produced in great numbers and are very showy, particularly in the culled forest. Perhaps the most striking flowers in the *Parashorea-Diplodiscus* association are those of the leguminous vine *Strongylodon macrobotrys.* These are large and bluish green and are crowded together on pendent racemes, which may be a meter in length. These racemes are not seen very frequently. At the higher altitudes in the dipterocarp forest climbing begonias sometimes produce very handsome displays.

The flowers in the undergrowth are not conspicuous as they are usually small and scattered.

The above list includes some of the most striking flowers in the forest, but only a small proportion of those that could be considered as showy. The flowers have, however, little influence on the appearance of the vegetation, as they are usually either borne at a great height or so few of them are produced at any one time that they are not conspicuous from the ground.

In a temperate-zone forest the dominant tree species are usually few in number, and so are favorably situated for wind pollenation. The majority of trees in such forests are thus pollenated, while showy flowers are confined largely to scattered and minor elements. The mixed dipterocarp forest contains very few wind-pollenated species. On the plot in the virgin dipterocarp forest there were ninety-two species of erect woody plants more than 2 meters in height. In many of these pollenation has not been observed, but with the exception of the palm *Livistona* sp. all appear to be adapted for insect pollenation. The method of pollenation in *Livistona* sp. is not known. The scarcity of wind-pollenated trees in the dipterocarp forest appears to be associated with the mixed composition of the forest. It seems surprising, therefore, that the small scattered species usually have inconspicuous flowers, while the gregarious, dominant dipterocarps frequently have showy displays.

SEASONAL CHANGES

The appearance of the vegetation varies slightly according to the season. During the dry season the shedding of leaves by the trees is conspicuous. At such times the ground is usually covered with leaves, and the view in the forest is more open than in more favorable weather. The trees are, however, by no means deciduous, and this difference in the density of the foliage would only be noticed by one familiar with the forest. A few minor changes occur with the seasons; as, for example, a species of *Selaginella* is very common in the wet season on cuts in the banks, but it disappears during the dry period.

GENERAL VIEW

We have seen that the *Parashorea-Diplodiscus* association on Maquiling is essentially a forest of large and medium-sized trees and that these compose the great bulk of the vegetation. Except for the arrangement in stories, with accompanying greater density of foliage, most of these trees are not very different in appearance from those in dicotyledonous forests in temperate countries.

The view of the large trees is, however, frequently obscured by the great development of small trees and vines, particularly rattans and climbing bamboos. Owing to this fact, it is the great development of foliage that gives character to the appearance of the vegetation rather than the trunks of the large trees. Plate VI, fig. 2, shows this characteristic very plainly. A striking contrast is afforded by Plate VIII, fig. 1, which represents the forest at an elevation of about 300 meters. All of the small trees and some even more than a meter in diameter were removed from this area in preparation for a coffee plantation. The number of large trees in this area is probably not greater than in that represented in Plate VI, fig. 2. Except when one looks up at the canopy, the view in the dipterocarp forest is usually that of a dense tangle of small trees and vines rather than of a forest of big trees. In better-developed dipterocarp forests the large trees are relatively very much more prominent,* while small trees and vines are less developed; see Plates IX and X.

If we were to sum up the impression made upon one in passing through the dipterocarp forest, it would be something like this: A tall, dense forest, in which large and small trees are crowded

* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

together until their leaves very fully occupy all the available space, while the ground is covered with a dense undergrowth consisting largely of feathery rattans, some of which reach up among the trees. Scattered here and there are tall palms, while now and then the eye is caught by a large tree with gigantic buttresses, the bizarre form of a strangling fig, the long leaves of the epiphytic bird's-nest fern, or a tree trunk covered with fruit.

BIZARRE PLANTS

The tropical forest is usually considered the special habitat of bizarre plants. Such plants occur in the forest under discussion, but with the exception of the strangling figs are not prominent.

In spots *Rafflesia manillana* is rather showy. Scattered through the forest are places several meters square where the roots of *Cissus* are either near or on the surface of the ground. Such roots may be thickly infested with *Rafflesia*.* Usually only a few flowers will be open at a time, but the buds are frequently numerous (Plate XV, fig. 2). When several of the flowers, which spring directly from the root of the host and are from 15 to 20 centimeters in diameter, are open at once, they are rather striking; but the patches are widely separated and affect the appearance of the forest so little that people usually become very familiar with it without noticing the *Rafflesia*.

Several interesting myrmecophilous plants are present but are rarely seen, as they are not abundant and are usually confined to the tops of the tall trees. *Hydnophytum* and *Myrmecodia* (Plates XIII, fig. 3, and XIV), with their large bulbous bases containing labyrinthian cavities, are occasionally found on fallen trees; while *Polypodium sinuatum,* with its enlarged, hollow stems, has been observed once. Probably more abundant than the above-mentioned species is *Dischidia purpurea,* a vine growing in close contact with the surface of the bark of a tree (Plate XIII, fig. 2). The edges of a leaf touch the bark while the center is raised, forming a cavity in which roots grow and which is inhabited by ants.

The leafless orchid *Taeniophyllum philippinense,* with its photosynthetic roots, is occasionally found on the trunks of trees; this is a small and very inconspicuous plant. *Galeola hydra,* a rare but conspicuous saprophytic orchid, is a vine, which may grow to be about 10 meters in length, and which has rather

* Brown, W. H., The relation of Rafflesia manillana to its host, *Phil. Journ. Sci., Sec. C* (1912), 7, 209–226.

large clusters of yellow flowers. Other saprophytes and parasites occur in this forest, but for the most part they are small and not striking in appearance. The previously mentioned humus-gathering ferns, *Drynaria quercifolia* and *Asplenium nidus*, are much more in evidence than the plants just mentioned.

In discussing the bizarre plants their scarcity has been emphasized. This feature is not peculiar to the dipterocarp forest of Mount Maquiling, but is characteristic of the tall forests of the Philippines. Most of the unusual forms of plants found in the Indo-Malayan region occur in the Philippines, and many of them are widely distributed, but they are usually of local occurrence. Bizarre plants, when they occur in more open and lower types of forest at high elevations, are frequently more evident than in the dipterocarp forest. It is from high-mountain forests that many of the current impressions of tropical forests have been obtained, as frequently the tall lowland forests have been removed for cultivation, while only the more inaccessible mountain forests have retained their virgin character. Most botanists in describing tropical forests mention only or chiefly peculiar characters which are of particular interest to botanists, and thus unintentionally give the impression that striking and bizarre plants are much more prominent than is the case.

In considering the question of peculiar plants it is well to bear in mind that people are apt to regard the things to which they are accustomed as usual and those to which they are unaccustomed as unusual. Thus one raised in a temperate country will think of the deciduous broad-leaved forest as a usual one, and of the tropical forest as strange and bizarre. On the other hand, the inhabitants of moist tropics look upon the deciduous forests in temperate regions as very strange. It is certainly reasonable to regard the broad-leaved, evergreen forests of the tropics as a generalized type; and the deciduous forest of temperate regions as fitted to adverse winter conditions, just as the thorny vegetation of desert regions is suited to a dry climate. Nor is there any reason to regard the presence of palms, tree ferns, and epiphytes as more peculiar than their absence, particularly as their absence is connected with adverse rather than favorable conditions. Likewise, a dense forest composed of many species should not be regarded as more peculiar than a more open one composed of a few species. Again, it may be pointed out that annual growth rings; winter protective bud-coverings; early spring bloomers; biennials; and many other features connected with the presence of a cold sea-

son are special adaptations. It seems well to emphasize the above points, as botanists from temperate regions are too apt to regard temperate vegetation as a generalized type and tropical vegetation as a specialized one, whereas there certainly are many reasons for considering the reverse as the more nearly correct view. Although all the fundamental features of botany are similar in tropical and temperate zones, elementary text-books prepared for temperate countries are not suitable for the tropics, because conditions connected with the winter season are treated as though they were not only the usual but also the generalized conditions. This method is natural and may be valuable in view of the use for which the books are prepared, but it would seem to have a tendency to leave an incorrect impression.

DESCRIPTION OF PLOT

In order to compare the physical characteristics of different types of vegetation, accurate measurements of the component parts are necessary. Such measurements are obtained only with difficulty in lofty forests that have the density and diversity found in the dipterocarp type, and the methods that ecologists have usually used in describing vegetation are not suitable for these forests.

Owing to the density of the stand and the size of the trees, it is impossible to measure the heights of the individuals in situ. Accurate measurements over extensive areas are therefore impracticable, while data from small plots do not give an adequate idea of the composition of the stand. For these reasons it seemed best to select a single fair-sized plot in each of the tall types of vegetation, particularly as the purpose of the present paper is to compare different formations rather than minor variations within a formation. The different plots used had similar slopes and exposures. Each of the three lower ones comprised an area 50 meters square. All of the plants on these plots were cut and removed, which made it possible to measure the individuals accurately and to utilize the plots for further experiments.

The plot in the virgin dipterocarp forest was at an altitude of approximately 450 meters, situated on the gently sloping side of a ridge, and fully exposed to sun and wind. All the plants were cut down, and each individual more than 2 meters in height was measured with a tape to ascertain its height and diameter. The clear length of trunk was also measured of all trees that were large enough to have trunks free from branches.

Buttresses were not included in the measurements of the diameters. The results of the measurements for the plot in the dipterocarp forest are given in Tables II to IX.

TABLE II.—*Stand of trees over 2 meters in height on 0.25 hectare in dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

No.	Species.	Individuals.	Greatest height on plot.	Greatest diameter on plot.	Volume of trees.[a] Total.	In third story (2 to 12 m. in height)	In second story (12 to 22 m. in height)	In first story (22 to 38 m. in height)
	FIRST-STORY SPECIES.		*m.*	*cm.*	*cu. m.*	*cu. m.*	*cu. m.*	*cu. m.*
	Dipterocarps:							
1	*Hopea acuminata* (dalingdiñgan)	1	2.40	2.0	------	------	------	------
2	*Parashorea malaanonan* (bagtican lauan)	29	35.95	96.0	18.47	------	2.25	16.22
3	*Shorea guiso* (guijo)	4	10.50	15.0	0.09	0.09	------	------
	Miscellaneous species:							
4	*Bischofia javanica* (tuai)	1	21.00	72.0	4.31	------	4.31	------
5	*Canarium luzonicum* (pili)	2	23.60	58.0	3.04	------	------	3.04
6	*Canarium villosum*	1	5.80	6.0	------	------	------	------
7	*Canarium* sp. (pagsahing)	6	10.10	17.0	0.07	0.07	------	------
8	*Canarium* sp	1	4.90	5.0	------	------	------	------
9	*Celtis philippensis* (malaicmo)	11	18.35	15.0	0.14	------	0.14	------
10	*Eugenia luzonensis* (malaruhat puti)	2	6.85	13.0	0.05	0.05	------	------
11	*Eugenia mananquil*	2	3.00	2.5	------	------	------	------
12	*Eugenia similis* (malaruhat)	3	26.00	95.0	8.92	------	------	8.92
13	*Eugenia* sp	1	2.30	2.5	------	------	------	------
14	*Meliosma macrophylla*	4	21.25	25.0	0.46	------	0.20	0.26
15	*Neonauclea* sp	4	28.40	50.0	5.38	------	1.01	4.37
16	*Palaquium tenuipetiolatum* (palac palac)	2	22.65	20.0	0.22	0.04	------	0.18
17	*Palaquium* sp	3	4.30	3.0	------	------	------	------
18	*Palaquium* sp	2	2.00	2.0	------	------	------	------
19	*Planchonia spectabilis* (lamog)	2	28.30	75.0	7.87	------	------	7.87
20	*Pterocymbium tinctorium*	1	2.50	1.5	------	------	------	------
21	*Sterculia* sp. (lapnit)	1	32.10	83.0	6.35	------	------	6.35
22	*Turpinia pomifera*	4	17.55	25.0	0.36	0.05	0.31	------
	SECOND-STORY SPECIES.							
23	*Aglaia diffusa* (salaquin pula)	1	2.10	1.5	------	------	------	------
24	*Aglaia* sp (malasaging)	11	17.10	30.0	0.38	0.09	0.29	------
25	*Alangium meyeri* (putian)	5	13.55	14.0	0.03	------	0.03	------
26	*Amoora* sp	5	6.00	8.0	------	------	------	------
27	*Ardisia boissieri* (tagpo)	4	14.15	25.0	0.39	0.11	0.28	------
28	*Ardisia perrottetiana*	3	9.20	8.0	------	------	------	------
29	*Ardisia* sp	1	2.70	2.0	------	------	------	------
30	*Chisocheton cumingianus* (salaquin-puti)	8	11.65	15.0	0.05	0.05	------	------
31	*Chisocheton pentandrus* (salaquin pula)	1	2.00	2.0	------	------	------	------

TABLE II.—*Stand of trees over 2 meters in height on 0.25 hectare in dipterocarp forest on Mount Maquiling; altitude, 450 meters*—Continued.

No.	Species.	Individuals.	Greatest height on plot.	Greatest diameter on plot.	Volume of trees.[a] Total.	In third story (2 to 12 m. in height)	In second story (12 to 22 m. in height)	In first story (22 to 38 m. in height)
	SECOND-STORY SPECIES—cont.		*m.*	*cm.*	*cu. m.*	*cu. m.*	*cu. m.*	*cu. m.*
32	Indt	1	17.40	25.0	0.21		0.21	
33	*Cinnamomum mercadoi* (calingag)	3	20.00	30.0	0.51	0.08	0.43	
34	*Cryptocarya lauriflora*	2	5.60	4.5				
35	*Cyclostemon* sp	3	4.17	4.5				
36	*Dillenia philippinensis* (catmon)	16	17.00	55.0	5.36	0.68	4.68	
37	*Dillenia reifferscheidia* (catmon)	1	14.20	45.0	0.78		0.78	
38	*Diospyros discolor* (camagon)	9	22.00	50.0	3.21		3.21	
39	*Diplodiscus paniculatus* (balobo)	28	19.20	38.0	1.37	0.25	1.12	
40	*Dysoxylum* sp	4	2.80	3.0				
41	*Euonymus javanica*	3	2.45	2.0				
42	*Euphoria cinerea* (alupag)	1	2.10	2.0				
43	*Evodia* sp	1	16.55	25.0	0.33		0.33	
44	*Ficus barnesii*	1	13.14	20.0	0.05		0.05	
45	*Ficus ribes* (auymit)	6	12.50	15.0	0.16	0.13	0.03	
46	*Ficus variegata* (tangisang biauac)	6	20.35	35.0	1.60		1.60	
47	*Ficus* sp	2	20.15	38.0	0.98		0.98	
48	*Garcinia binucao* (binucao)	1	2.95	2.5				
49	*Garcinia venulosa* (gatásan)	2	9.80	16.0	0.07	0.07		
50	*Gymnacranthera paniculata* (tambulao)	2	3.10	4.0				
51	*Litsea garciae*	3	17.50	35.0	1.12		1.12	
52	*Livistona* sp. (anahau)	13	18.00	21.0				
53	*Lophopetalum toxicum* (calatumbago)	3	24.00	30.0	1.11	0.06	0.48	0.57
54	*Mastixia philippinensis* (tapulao)	3	3.07	3.0				
55	*Memecylon paniculatum* (culis)	2	2.10	2.5				
56	*Nauclea junghuhnii* (mambog)	4	13.00	25.0	0.38	0.04	0.34	
57	*Neonauclea calycina*	3	16.85	21.0	0.06		0.06	
58	*Neonauclea media*	1	5.35	8.0				
59	*Nephelium mutabile* (bulala)	10	23.00	42.0	1.69	0.08	0.44	1.17
60	*Pisonia umbellifera* (anuling)	1	7.20	8.0				
61	*Papualthia lanceolata* (lanutan)	3	9.20	11.0				
62	*Semecarpus gigantifolia* (ligas)	1	19.00	30.0	0.43		0.43	
63	*Strombosia philippinensis* (tamayuan)	1	3.90	3.0				
64	*Symplocos* sp	1	3.20	3.5				
65	*Terminalia pellucida* (calumpit)	1	8.15	8.0				
	THIRD-STORY SPECIES.							
66	*Ficus minahassae* (hagimit)	1	10.05	3.0				
67	*Flacourtia* sp	2	2.40	2.0				
68	*Garcinia rubra*	1	7.00	7.0				
69	*Glochidion lancifolium*	1	3.07	3.0				
70	*Glochidion* sp	2	4.06	6.0				
71	*Goniothalamus elmeri*	3	4.40	5.0				
72	*Grewia stylocarpa* (susumbic)	9	10.72	17.0	0.01	0.01		
73	*Ixora longistipula*	1	2.20	2.0				

TABLE II.—*Stand of trees over 2 meters in height on 0.25 hectare in dipterocarp forest on Mount Maquiling; altitude, 450 meters*—Continued.

No.	Species.	Individuals.	Greatest height on plot.	Greatest diameter on plot.	Volume of trees.[a] Total.	In third story (2 to 12 m. in height)	In second story (12 to 22 m. in height)	In first story (22 to 38 m. in height)
	THIRD-STORY SPECIES—continued.		*m.*	*cm.*	*cu. m.*	*cu. m.*	*cu. m.*	*cu. m.*
74	*Ixora macrophylla*	2	6.15	6.0				
75	*Laportea subclausa* (lipa)	12	10.20	10.0	0.02	0.02		
76	*Leea aculeata*	3	2.90	3.0				
77	*Leea manillensis*	15	11.20	8.0				
78	*Leea philippinensis*	2	10.90	10.0	0.02	0.02		
79	*Leucosyke capitellata* (lagasi)	1	3.30	3.0				
80	*Macaranga bicolor* (hamindang)	1	11.60	12.0	0.06	0.06		
81	*Macaranga grandifolia* (taquip asin)	3	12.40	15.0	0.03	0.03		
82	*Mallotus ricinoides* (hinlaumo)	1	2.50	2.0				
83	*Neolitsea villosa*	2	8.95	10.0	0.03	0.03		
84	*Neotrewia cumingii* (batobato)	3	5.00	7.0				
85	*Oreocnide trinervis* (malatuba)	9	8.25	12.0	0.01	0.01		
86	*Sambucus javanica*	1	2.00	1.5				
87	*Saurauia latebracteata*	2	10.20	25.0	0.17	0.17		
88	*Saurauia* sp.	2	6.60	7.0				
	UNDERGROWTH SPECIES.							
89	*Callicarpa erioclona*	1	2.10	1.0				
90	*Clerodendron quadriloculare*	1	3.70	2.0				
91	*Tabernaemontana pandacaqui* (pandacaqui)	3	4.50	5.5				
92	*Wickstroemia meyeniana*	1	2.08	1.5				
	Total	353			76.35	2.29	25.11	48.95

[a] The volume of trees less than 10 centimeters in diameter is omitted.

TABLE III.—*Summary of composition of volume*[a] *of different stories on 0.25 hectare in dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

Story to which species belong when the individuals mature.	Stories in which the individuals present were found. First story. (Height, 22 to 38 m.)	Second story. (Height, 12 to 22 m.)	Third story. (Height, 2 to 12 m.)	Total.	
	cu. m.	*cu. m.*	*cu. m.*	*cu. m.*	*Per cent.*
First-story species	47.21	8.22	0.30	55.73	73.0
Second-story species	1.74	16.89	1.64	20.27	26.5
Third-story species			0.35	0.35	0.5
Undergrowth species					
Total	48.95	25.11	2.29	76.35	100.0

[a] The volume of trees less than 10 centimeters in diameter is omitted.

In Table II the species are arranged according to the stories in which the mature individuals occur. This classification is necessarily inexact, as not all specimens of a single species attain the same size or form. Individuals of species usually occurring in the second or third story may be in an exceptionally favorable situation and attain a height sufficient to place them in the story next higher than that in which they are usually found. On the other hand, individuals of species that are usually large may be dwarfed and never reach the story to which the species properly belongs. The species are placed in the story in which mature specimens have usually been found. The species in a story vary considerably in size, some being nearer than others to the border line between the stories.

Some of the species occur only as very scattered individuals, and a few may be placed in the wrong story owing to a lack of thorough acquaintance with the species. In Table II are listed nineteen which are identified only as to the genus and one unidentified species. Many of them are better known than this would indicate, and in most cases the species can be readily assigned to the proper story. In a few instances this could not be done with certainty, but probably few if any of the species are placed in the wrong story.

In preparing a table it is convenient to adopt arbitrary limits for the different stories. In Table II trees from 22 to 38 meters in height are regarded as being in the first story; those from 12 to 22 meters, as composing the second story; and those from 2 to 12 meters high, as forming the third. In most cases this arbitrary classification throws the trees into the stories in which they properly belong. Some of the individuals whose tops are near the border line between two stories may be thrown into a story that contains only a small part of the crown; but this error is not serious, as such individuals can usually be regarded as belonging to either story.

In Table II is given the number of individuals of each species on the plot, as well as the greatest height and largest diameter attained by each species, and the volume arranged according to the story in which the individuals were found.

There were in all 92 species and 353 individuals of erect woody plants more than 2 meters in height on this plot. Thirty-two, or more than one-third of the species, were represented by only one individual. This would indicate that, had the plot been larger, the number of species would have been greater. An examination of the surrounding vegetation showed this to be true.

There were on the plot 22 first-story species, 43 second-story, and 23 third-story species. The second-story species are smaller than those in the first, and there are naturally more individuals present in the story containing the smaller species. This fact may account to some extent for the presence of about twice as many species of second- as of first-story trees. The third-story species are small, but there is only one more of these species than there are of the first story. The former have the disadvantage of being heavily shaded and of having to compete with small individuals of the higher stories. In the general discussion it was pointed out that there are many more species of second-story trees in the *Parashorea-Diplodiscus* association than there are of either first- or third-story species.

In Table IV are given the heights of all individuals more than 2 meters tall. The results of this table are summarized in Table V. An examination of Table V shows that the individuals of first-, second-, and third-story species are present in about the same proportion as the species themselves. That is, the number of individuals belonging to first-story species is not very different from the number belonging to third-story species, while the individuals of second-story species are about as numerous as those of both of the other stories together. The number of species of second-story trees is 96 per cent of that of both first- and third-story species, while the number of individuals of second-story trees is 109 per cent as great as that of individuals of both first- and third-story species.

TABLE IV.—*Height of all trees over 2 meters high on 0.25 hectare in dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Figures represent numbers of individuals.]

No.	Species.	Height in meters.									
		2 to 6.	6 to 10.	10 to 12.	12 to 14.	14 to 18.	18 to 22.	22 to 26.	26 to 30.	30 to 34.	34 to 38.
	FIRST-STORY SPECIES.										
	Dipterocarps:										
1	*Hopea acuminata* (dalingdiñgan)	1									
2	*Parashorea malaanonan* (bagtican lauan)	20	1		1		2	3			2
3	*Shorea guiso* (guijo)	2	1	1							
	Miscellaneous species:										
4	*Bischofia javanica* (tuai)						1				
5	*Canarium luzonicum* (pili)	1						1			
6	*Canarium villosum* (pagsahing)	1									

TABLE IV.—*Height of all trees over 2 meters high on 0.25 hectare in dipterocarp forest on Mount Maquiling; altitude, 450 meters*—Continued.

No.	Species.	Height in meters.									
		2 to 6.	6 to 10.	10 to 12.	12 to 14.	14 to 18.	18 to 22.	22 to 26.	26 to 30.	30 to 34.	34 to 38.
	FIRST-STORY SPECIES—cont.										
	Miscellaneous species—Cont.										
7	*Canarium* sp. (pagsahing)	2	3	1							
8	*Canarium* sp	1									
9	*Celtis philippensis* (malaicmo)	6	3		1		1				
10	*Eugenia luzonensis* (malaruhat puti)	1	1								
11	*Eugenia mananquil*	2									
12	*Eugenia similis* (malaruhat)	2						1			
13	*Eugenia* sp	1									
14	*Meliosma macrophylla*	2			1		1				
15	*Neonauclea* sp					1			3		
16	*Palaquium tenuipetiolatum* (palac palac)		1					1			
17	*Palaquium* sp	3									
18	*Palaquium* sp	2									
19	*Planchonia spectabilis* (lamog)							1	1		
20	*Pterocymbium tinctorium* (taluto)	1									
21	*Sterculia* sp. (lapnit)									1	
22	*Turpinia pomifera* (malabago)	1		1	1	1					
	SECOND-STORY SPECIES.										
23	*Aglaia diffusa* (salaquin pula)	1									
24	*Aglaia* sp. (malasaging)	8	1	1		1					
25	*Alangium meyeri* (putian)	3	1		1						
26	*Amoora* sp	5									
27	*Ardisia boissieri* (tagpo)	1	2			1					
28	*Ardisia perrottetiana*	1	2								
29	*Ardisia* sp	1									
30	*Chisocheton cumingianus* (salaquin-puti)	5	1	2							
31	*Chisocheton pentandrus* (salaquin pula)	1									
32	Indt					1					
33	*Cinnamomum mercadoi* (calingag)	1		1			1				
34	*Cryptocarya lauriflora*	2									
35	*Cyclostemon* sp	3									
36	*Dillenia philippinensis* (catmon)	2	2	3	3	6					
37	*Dillenia reifferscheidia* (catmon)					1					
38	*Diospyros discolor* (camagon)	2	2	1	1		3				
39	*Diplodiscus paniculatus* (balobo)	20	4	1	2		1				

TABLE IV.—*Height of all trees over 2 meters high on 0.25 hectare in dipterocarp forest on Mount Maquiling; altitude, 450 meters*—Continued.

No.	Species.	Height in meters.									
		2 to 6.	6 to 10.	10 to 12.	12 to 14.	14 to 18.	18 to 22.	22 to 26.	26 to 30.	30 to 34.	34 to 38.
	SECOND-STORY SPECIES—cont.										
40	*Dysoxylum* sp	4									
41	*Euonymus javanica*	3									
42	*Euphoria cinerea* (alupag)	1									
43	*Evodia* sp					1					
44	*Ficus barnesii*				1						
45	*Ficus ribes* (auymit)	1	3	1	1						
46	*Ficus variegata* (tangisang biauac)	2	2			1	1				
47	*Ficus* sp					1	1				
48	*Garcinia binucao*	1									
49	*Garcinia venulosa* (gatásan)	1	1								
50	*Gymnacranthera paniculata* (tambulao)	2									
51	*Litsea garciae*				2	1					
52	*Livistona* sp. (anahau)	3	3	2	2	3					
53	*Lophopetalum toxicum* (calatumbago)		1				1	1			
54	*Mastixia philippinensis* (tapulao)	3									
55	*Memecylon paniculatum* (culis)	2									
56	*Nauclea junghuhnii* (mambog)	2		1	1						
57	*Neonauclea calycina*	2				1					
58	*Neonauclea media*	1									
59	*Nephelium mutabile* (bulala)	6	2				1	1			
60	*Pisonia umbellifera* (anuling)		1								
61	*Papualthia lanceolata* (lanutan)	2	1								
62	*Semecarpus gigantifolia* (ligas)						1				
63	*Strombosia philippinensis* (tamayuan)	1									
64	*Symplocos* sp	1									
65	*Terminalia pellucida* (calumpit)		1								
	THIRD-STORY SPECIES.										
66	*Ficus minahassae* (hagimit)			1							
67	*Flacourtia* sp	2									
68	*Garcinia rubra*		1								
69	*Glochidion lancifolium*	1									
70	*Glochidion* sp	2									
71	*Goniothalamus elmeri*	3									
72	*Grewia stylocarpa* (susumbic)	7	1	1							
73	*Ixora longistipula*	1									
74	*Ixora macrophylla*	1	1								
75	*Laportea subclausa* (lipa)	11		1							
76	*Leea aculeata*	3									
77	*Leea manillensis*	9	5	1							

TABLE IV.—*Height of all trees over 2 meters high on 0.25 hectare in dipterocarp forest on Mount Maquiling; altitude, 450 meters*—Continued.

No.	Species.	Height in meters.									
		2 to 6.	6 to 10.	10 to 12.	12 to 14.	14 to 18.	18 to 22.	22 to 26.	26 to 30.	30 to 34.	34 to 38.
	THIRD-STORY SPECIES—cont.										
78	*Leea philippinensis*	1		1							
79	*Leucosyke capitellata* (lagasi)	1									
80	*Macaranga bicolor* (hamindang)			1							
81	*Macaranga grandifolia* (taquip asin)		2		1						
82	*Mallotus ricinoides* (hinlaumo)	1									
83	*Neolitsea villosa*	1	1								
84	*Neotrewia cumingii* (batobato)	3									
85	*Oreocnide trinervis*	7	2								
86	*Sambucus javanica*	1									
87	*Saurauia latebracteata*	1		1							
88	*Saurauia* sp	1	1								
	UNDERGROWTH SPECIES.										
89	*Callicarpa erioclona*	1									
90	*Clerodendron quadriloculare*	1									
91	*Tabernaemontana pandacaqui* (pandacaqui)	3									
92	*Wickstroemia meyeniana*	1									
	Total	206	54	23	19	20	15	9	4	1	2

TABLE V.—*Summary of the composition of different stories in the dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Figures represent numbers of individuals.]

Story to which species belong when the individuals are mature.	Stories in which the individuals present were found.			Total.
	First story; height, 22 to 38 m.	Second story; height, 12 to 22 m.	Third story; height, 2 to 12 m.	
First-story	14	11	62	87
Second-story	2	42	137	181
Third-story		1	78	79
Undergrowth			6	6
Total	16	54	283	353

The total number of individuals in the first story was 16. Owing to their size these formed a practically closed canopy. The second-story trees were smaller, and there were 54 present in the second story, or 3.4 times as many individuals as in the

first story. In the third story there were 283 individuals, or 5.2 times as many as in the second story and 17.7 times as many as in the first story. The large number present in the third story is evidently connected with the small size of the trees. The third story consists largely of individuals belonging to stories other than the third, the latter species composing only 27.6 per cent of the total number of individuals present, while the second-story species are represented by 48.4 per cent. In the second story 77.8 per cent of the trees belong to second-story species.

An examination of Table IV shows that most of the trees of any story reach only to the lower portions of the story. This is particularly true of the third story. The individuals between 2 and 6 meters in height form 72.8 per cent of the total number of those in the third story and 58.4 per cent of all erect woody plants more than 2 meters high that were on the plot.

Table II shows that *Parashorea malaanonan* and *Diplodiscus paniculatus* were by far the most numerous species on the plot, while from Table IV it will be seen that *Parashorea* is represented by more large trees than is any other species.

In Table II are given the volume of each species in the different stories and the total for each species. The figures represent the volume in cubic meters of the part of the trunk that was clear of branches. The volume of trees less than 10 centimeters in diameter was very small and was omitted from the tables. The total volume was 76.35 cubic meters. The volume of *Parashorea* was 2.1 times as great as that of any other species and was 24.2 per cent of the total volume on the plot. *Parashorea* composed a larger proportion, 33.1 per cent, of the volume of the first story than of the volume as a whole.

The volume shown in Table II is not large for a dipterocarp forest, and the percentage of dipterocarp timber by volume is low. Measurements made by Everett and Whitford * in the forest of northern Negros showed a volume of 519.58 cubic meters to the hectare, and more than 95 per cent of this belonged to members of the family Dipterocarpaceae. Plate IX and Plate X, fig. 1, show views in this forest.

Table III gives a summary of the volume of the different stories in the Maquiling forest. Of the total volume of 76.35 cubic meters 55.73, or 73 per cent, belong to first-story species;

* Everett, H. D., and Whitford, H. N., A Preliminary Working Plan for the Public Forest Tract of the Insular Lumber Company, Occidental Negros, P. I., *Bull. P. I. Bur. For.* (1906), No. 5. Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

20.27 cubic meters, or 26.5 per cent, to second-story species; while third-story species are represented by only 0.35 cubic meter, or 0.5 per cent. The volume is not only concentrated in first-story species, but 47.21 cubic meters, or 61.8 per cent of the total volume, are of these species within the first story.

The first story contained 48.95 cubic meters, or 64.1 per cent of the total; the second story 25.11 cubic meters, or 32.9 per cent; and the third story 2.29 cubic meters, or 3 per cent. These figures, considered in connection with the number of trees in the various stories, show a very striking difference in the size of the individuals composing them. In the first story there were 16 trees containing 48.95 cubic meters of timber, an average of 3.1 cubic meters to a tree. The second story contained 54 individuals with an average volume of 0.46 cubic meter. The volume of third-story trees less than 10 centimeters in diameter is not included in the table. The 2.29 cubic meters in this story were, therefore, in the 37 individuals more than 10 centimeters in diameter, the average per tree being 0.062 cubic meter. The figure would, of course, have been very much smaller had it been based on the 283 trees comprising the third story.

Table VI gives the diameter classes of all trees over 10 centimeters in diameter on the plot. The largest number belonging to any one species was 13, of *Dillenia philippinensis*, a second-story species. *Parashorea malaanonan* and *Livistona* sp., the latter a palm, were represented by 8 individuals each. The specimens of *Livistona* were relatively small while, as in previous tables, *Parashorea* was the most conspicuous large tree. In all there were 107 trees more than 10 centimeters in diameter, distributed in 36 genera and 43 species.

TABLE VI.—*Diameter classes of all trees over 10 centimeters in diameter on 0.25 hectare in dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Figures represent numbers of individuals.]

No.	Species.	Diameter class in centimeters.									Total.
		10 to 20.	20 to 30.	30 to 40.	40 to 50.	50 to 60.	60 to 70.	70 to 80.	80 to 90.	90 to 100.	
	FIRST-STORY SPECIES.										
	Dipterocarps:										
1	*Parashorea malaanonan* (bagtican lauan)	1	1	4		1				1	8
2	*Shorea guiso* (guijo)	1									1
	Miscellaneous species:										
3	*Bischofia javanica* (tuai)							1			1

TABLE VI.—*Diameter classes of all trees over 10 centimeters in diameter on 0.25 hectare in dipterocarp forest on Mount Maquiling; altitude, 450 meters*—Continued.

No.	Species.	Diameter class in centimeters.									Total.
		10 to 20.	20 to 30.	30 to 40.	40 to 50.	50 to 60.	60 to 70.	70 to 80.	80 to 90.	90 to 100.	
	FIRST-STORY SPECIES—cont.										
	Miscellaneous species—Cont.										
4	*Canarium luzonicum* (pili)					1					1
5	*Canarium* sp. (pagsahing)	2									2
6	*Celtis philippensis* (malaicmo)	3									3
7	*Eugenia luzonensis* (malaruhat puti)	1									1
8	*Eugenia similis* (malaruhat)									1	1
9	*Meliosma macrophylla*	1	1								2
10	*Neonauclea* sp			2	2						4
11	*Palaquium tenuipetiolatum* (palac palac)	2									2
12	*Planchonia spectabilis* (lamog)				1			1			2
13	*Sterculia* sp. (lapnit)								1		1
14	*Turpinia pomifera*	2	1								3
	SECOND-STORY SPECIES.										
15	*Aglaia* sp. (malasaging)	2	1								3
16	*Alangium meyeri* (putian)	1									1
17	*Ardisia boissieri* (tagpo)	2	1								3
18	*Chisocheton cumingianus* (salaquin-puti)	2									2
19	Indt		1								1
20	*Cinnamomum mercadoi* (calingag)	1	1								2
21	*Dillenia philippinensis* (catmon)	2	4	4	2	1					13
22	*Dillenia reifferscheidia* (catmon)				1						1
23	*Diospyros discolor* (camagon)	1	1	1	1						4
24	*Diplodiscus paniculatus* (balobo)	1	1	2							4
25	*Evodia* sp		1								1
26	*Ficus barnesii*	1									1
27	*Ficus ribes* (auymit)	4									4
28	*Ficus variegata* (tangisang biauac)	1		2							3
29	*Ficus* sp		1	1							2
30	*Garcinia venulosa* (gatásan)	1									1
31	*Litsea garciae*	2		1							3
32	*Livistona* sp. (anahau)	7	1								8
33	*Lophopetalum toxicum*	1	2								3
34	*Nauclea junghuhnii* (mambog)	1	1								2
35	*Neonauclea calycina*		1								1

TABLE VI.—*Diameter classes of all trees over 10 centimeters in diameter on 0.25 hectare in dipterocarp forest on Mount Maquiling; altitude, 450 meters*—Continued.

No.	Species.	Diameter class in centimeters.									Total.
		10 to 20.	20 to 30.	30 to 40.	40 to 50.	50 to 60.	60 to 70.	70 to 80.	80 to 90.	90 to 100.	
	SECOND-STORY SPECIES—cont.										
36	*Nephelium mutabile* (bulala)	1	1		1						3
37	*Papualthia lanceolata* (lanutan)	1									1
38	*Semecarpus gigantifolia* (ligas)		1								1
	THIRD-STORY SPECIES.										
39	*Grewia stylocarpa* (susumbic)	2									2
40	*Macaranga bicolor* (hamindang)	1									1
41	*Macaranga grandifolia* (taquip asin)	2									2
42	*Oreocnide trinervis* (malatuba)	1									1
43	*Saurauia latebracteata*		1								1
	Total	51	23	17	8	3	0	2	1	2	107

In Table VII are given the diameter classes of the same 107 trees distributed according to the story in which they occurred, and not according to that to which the species usually belong

TABLE VII.—*Diameter classes of trees over 10 centimeters in diameter in the different stories on 0.25 hectare in dipterocarp forest, Mount Maquiling; altitude, 450 meters.*

[Figures represent numbers of individuals.]

Story.	Diameter class in centimeters.									Total.	Average diameter.[a]
	10 to 20.	20 to 30.	30 to 40.	40 to 50.	50 to 60.	60 to 70.	70 to 80.	80 to 90.	90 to 100.		*cm.*
First story	1	2	3	4	2		1	1	2	16	52.9
Second story	17	18	13	4	1		1			54	28.4
Third story	33	3	1							37	15.6
Total	51	23	17	8	3		2	1	2	107	

[a] The average diameters were calculated from the exact measurements and not from the figures in this table.

when mature. The range of diameter classes for the first and second stories is not so different as might have been expected. Both stories have trees in the 10- to 20-centimeter class. The only first-story tree in this class, however, was just small enough to be included, as it was 20 centimeters in diameter. The largest diameters of first-story trees were between 90 and 100 centimeters, while a second-story tree is included in the 70- to 80-centimeter class. The latter was an old individual of *Bischofia javanica,* a first-story species. It is probable that this tree formerly reached into the first story.

The average diameter of trees in the three stories is very different, that of the first story being 52.9 centimeters, the second 28.4, while that of the third-story trees that were more than 10 centimeters in diameter was 15.6 centimeters. The average diameter of all individuals of first-story species in the first story was 55.4 centimeters; of second-story species in the second story, 28.9 centimeters; and of third-story species in the third story, 16 centimeters. These averages are very similar to those just given for all of the trees in the different stories. Table VII shows that there are comparatively few second-story trees more than 40 centimeters in diameter, while most of the third-story individuals are less than 20. The third story contained 246 individuals less than 10 centimeters in diameter, which were not included in Tables VI and VII.

The average height of all first-story trees was 27.2 meters; of second-story individuals, 16.4 meters; while the third-story trees more than 10 centimeters in diameter averaged 9.8 meters. If these figures are compared with the average diameters of trees in the different stories it will be seen that, as a higher story is reached, the percentage of increase is greater for the diameters than for the heights. First-story trees have an average height that is fifty-one times as great as the average diameter; in the second story the average height is fifty-eight times as great as the average diameter; while third-story trees more than 10 centimeters in diameter have an average height sixty-three times as great as the average diameter.

TABLE VIII.—*Clear lengths of first-story trees 22 to 38 meters in height on 0.25 hectare in dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Figures represent numbers of individuals.]

No.	Species.	Clear length in meters.						Total.
		10 to 12.	12 to 14.	14 to 16.	16 to 18.	18 to 20.	20 to 22.	
1	*Parashorea malaanonan* (bagtican lauan)		1	2	1		1	5
2	*Canarium luzonicum* (pili)			1				1
3	*Eugenia similis* (malaruhat)			1				1
4	*Neonauclea* sp.	1	1	1				3
5	*Palaquium tenuipetiolatum* (palac palac)	1						1
6	*Planchonia spectabilis* (lamog)		1	1				2
7	*Sterculia* sp. (lapnit)				1			1
	Total	2	3	6	2		1	14

Table VIII gives the clear lengths of the trunks of all first-story trees in the first story, and Table IX of all second-story trees in the second story. From Table VIII it will be seen that no first-story tree had a clear length of more than 22 meters, or in other words part of the crown of all the individuals was in the space considered as being occupied by the second story. The average clear length of all the trees was 14.1 meters. If this figure is compared with the heights of the same individuals, it will be seen that a larger part of the length of the average crown is below rather than above a height of 22 meters. From Table VIII it will be seen that two of the first-story trees have branches below 12 meters, or within the third story. These figures show that there is no sharp dividing line between the crowns of the first and second stories, but that the higher branches of the second-story trees reach up among the lower branches of the first story. In a forest the lower leaves of a tree are frequently at a much greater height than the origin of the first branches, so that there is not as much overlapping of canopy as of branches in first- and second-story trees. It is, however, natural that there should be considerable intermingling of the lower part of the canopy of the first story and the upper part of that of the second story.

TABLE IX.—*Clear length of second-story trees 12 to 24 meters in height on 0.25 hectare in dipterocarp forest on Mount Maquiling; altitude, 450 meters.*[a]

[Figures represent numbers of individuals.]

No.	Species.	Clear lengths in meters.						Total.
		2 to 4.	4 to 6.	6 to 8.	8 to 10.	10 to 12.	12 to 14.	
1	*Aglaia* sp. (malasaging)		1					1
2	*Alangium meyeri* (putian)		1					1
3	*Ardisia boissieri* (tagpo)			1				1
4	Indt		1					1
5	*Cinnamomum mercadoi* (calingag)			1				1
6	*Dillenia philippinensis* (catmon)	2		4	1	1	1	9
7	*Dillenia reifferscheidia* (catmon)		1					1
8	*Diospyros discolor* (camagon)			1		2	1	4
9	*Diplodiscus paniculatus* (balobo)	1	1	1				3
10	*Evodia* sp					1		1
11	*Ficus barnesii*		1					1
12	*Ficus ribes* (auymit)	1						1
13	*Ficus variegata* (tangisang biauac)			1	1			2
14	*Ficus* sp	1	1					2
15	*Litsea garciae*				2	1		3
16	*Lophopetalum toxicum* (calatumbago)				1			1
17	*Nauclea junghuhnii* (mambog)				1			1
18	*Neonauclea calycina*		1					1
19	*Nephelium mutabile* (bulala)				1			1
20	*Semecarpus gigantifolia* (ligas)			1				1
	Total	5	8	10	7	5	2	37

[a] *Livistona* sp., a palm, is not included in this table.

Table IX shows that out of 37 second-story species in the second story 35 had clear trunks less than 12 meters in length. The average clear length of all trees was 8 meters. These figures show that there was an intermingling of branches between the second and third stories similar to that described for the first and second stories.

GROUND COVERING OF PLOT

In clearing the plot just described an area 10 meters square was selected, and an enumeration was made of all terrestrial plants growing on it; the results are given in Table X. The

TABLE X.—*Composition of plot 10 meters square in dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Figures represent numbers of individuals.]

No.	Species.	Height in meters.					Total.
		0 to 1.	1 to 2.	2 to 12.	12 to 22.	22 to 38.	
	TREES.						
1	*Aglaia* sp. (malasaging)	9		1			10
2	*Alangium meyeri* (putian)				1		1
3	*Ardisia boissieri* (tagpo)	1					1
4	*Ardisia perrottetiana*			1			1
5	*Ardisia* sp	1					1
6	*Canarium luzonicum* (pili)			1			1
7	*Canarium* sp			3			3
8	*Celtis philippensis* (malaicmo)		1				1
9	*Cinnamomum mercadoi* (calingag)	2					2
10	*Clerodendron quadriloculare*			1			1
11	*Cryptocarya lauriflora*	8	1				9
12	*Dillenia philippinensis* (catmon)	1		1			2
13	*Dimorphocalyx luzoniensis*		1				1
14	*Diospyros discolor*	1					1
15	*Diplodiscus paniculatus* (balobo)	51	2	2	1		56
16	*Dysoxylum* sp	1					1
17	*Eugenia saligna*		1				1
18	*Eugenia* sp		1				1
19	*Eugenia* sp	2	1				3
20	*Euonymus javanica*	2					2
21	*Ficus ribes* (auymit)				1		1
22	*Garcinia binucao* (binucao)			1			1
23	*Grewia stylocarpa* (susumbic)	2					2
24	*Ixora longistipula*	1					1
25	*Knema glomerata* (tambalao)	3					3
26	*Laportea subclausa* (lipa)	3		1			4
27	*Leea aculeata*			1			1
28	*Leea manillensis*	1		7			8
29	*Livistona* sp	1					1
30	*Neolitsea* sp	1					1
31	*Palaquium* sp	7		1			8
32	*Parashorea malaanonan* (bagtican lauan)				1		1
33	*Pinanga* sp	15					15
34	*Planchonia spectabilis* (lamog)	7					7
35	*Pterocymbium tinctorium* (taluto)	2	2				4
36	*Radermachera* sp		1				1
37	*Semecarpus* sp	1					1
38	Miscellaneous indt	28					28
	Total	151	11	21	4		187
	SHRUB.						
39	*Tabernaemontana pandacaqui* (pandacaqui)	1					1

TABLE X.—*Composition of plot 10 meters square in dipterocarp forest on Mount Maquiling; altitude, 450 meters*—Continued.

No.	Species.	Height in meters.					Total.
		0 to 1.	1 to 2.	2 to 12.	12 to 22.	22 to 28.	
	HERBS.						
40	*Alpinia brevilabris*	1					1
41	*Chloranthus officinalis*	13					13
42	*Donax cannaeformis*	19					19
43	*Hemigraphis strigosa*	7					7
44	*Phacelophrynium* sp	10					10
45	*Pteris quadriaurita*	1					1
46	*Rungia* sp	14					14
47	*Tectaria* sp	1					1
	Total	66					66
	VINES.						
48	*Agelaea* sp	53					53
49	*Alyxia monilifera*	1					1
50	Araceae	1					1
51	*Calamus* and *Daemonorops* spp	53	15	13	1		82
52	*Freycinetia williamsii*	4					4
53	*Lygodium circinnatum*	3					3
54	*Pothos* sp	3					3
55	*Schizostachyum diffusum*	2					2
56	Miscellaneous indt	89					89
	Total	209	15	13	1		238
	Total of all plants	427	26	34	5		492

total number of plants was 492. Of these, 427 were less than 1 meter high, 26 were between 1 and 2 meters; and 39 were more than 2 meters in height. There were 238 vines, 187 plants of tree species, 66 herbs, and 1 shrub. Of plants less than 1 meter high 209 were vines, 151 were tree species, 66 were herbs, and 1 was a shrub. With the exception of some of the herbs, most of these were seedlings, and only a small percentage of them stood any chance of reaching maturity. In the case of the tree species this is evident when it is considered that there were 151 individuals less than a meter in height on 100 square meters, and only 353 that were more than 2 meters high on 2,500 square meters. In the first case there were 1.51 seedlings and in the second 0.14 tree to the square meter.

Herbs were represented by 8 species. These are, perhaps, best described as mesophytes; certainly not one of them is a hydrophyte. *Alpinia brevilabris, Chloranthus officinalis,* and *Donax cannaeformis* are among the commonest herbs in the forest. The herbs, including seedlings, were scattered over the plot at the rate of one to every 1.5 square meters. It is evident from this that the herbs were not a prominent part of the vegetation.

The most conspicuous vines were the rattans *Calamus* and *Daemonorops*, of which there were 82 specimens. Of these there were 15 between 1 and 2 meters high, 13 between 2 and 12 meters, and 1 that was 15.3 meters in length. This number of young rattans is not unusually large. Their long leaves are the most striking feature of the undergrowth.

There were on the plot 427 plants less than 1 meter in height, or 4.27 to the square meter. This shows that the ground itself is not covered by a carpet of vegetation. Density is characteristic of the undergrowth rather than the ground covering, the soil being usually visible, except when covered with leaves, as is frequently the case in the dry season.

The unidentified specimens of vines and tree seedlings, shown in Table X, represented a number of species. On this plot, 10 meters square, there were certainly more than 75 species of terrestrial plants.

CULLED DIPTEROCARP FOREST

We have noted that the composition of the dipterocarp forest at elevations below 300 meters has been changed from its original condition by a system of selective logging. Naturally, the results are most marked near the lower edge of the forest and much less evident as higher elevations are reached. At about 300 meters' altitude many of the trees most valuable for commercial purposes have been removed; however, only the best specimens of the most highly prized species have been logged, and the physical character of the forest as a whole has probably not been greatly changed. Near the lower edge of the forest almost all good specimens of the valuable species and many of the better individuals of poorer ones have been removed.

At elevations of about 200 meters the original forest must have been much more largely dipterocarp than that now existing at elevations above 300 meters. Brown and Matthews * have shown that in the Philippines dipterocarp forests are better developed at lower elevations than at higher. That this is true of the forest on Maquiling also is indicated by the present distribution of seedlings and small trees. At an altitude of about 200 meters there are now present sufficiently large numbers of seedlings and small individuals of the valuable dipterocarps *Pentacme contorta* (white lauan) and *Shorea guiso* (guijo) to make it probable that these species were nearly as prominent in this area as *Parashorea malaanonan* (bagtican lauan). It seems likely, therefore, that the dipterocarps formed most of the first

* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

story and that this was more regular and had a higher average height than the virgin forest which has already been discussed.

This culled forest is not so directly connected with the present problem as is the more virgin forest at higher elevations; but a study of it will be of help in understanding the latter and, by giving an idea of the original composition, will aid in tracing the changes which naturally occur in the physical type of vegetation from the base to the summit of the mountain. The problem of how this culled forest can be restored to its original condition is a very practical one and has been discussed by Brown and Matthews.*

If the culled forest were to be placed in a formation named from the first- and second-story species most prominent in their respective stories, it would be in the *Parashorea-Diplodiscus* association. The wood of *Parashorea malaanonan* (bagtican lauan) is not resistant enough to termite and fungus attacks to be considered valuable in the Philippines; and, as the large trees of this species are difficult to handle with the primitive methods of logging that have been used on Mount Maquiling, *Parashorea* is very conspicuously the commonest of the very large trees found in the culled forest. Likewise the wood of *Diplodiscus paniculatus* (balobo) is not regarded as being of good quality, and this species is probably even more prominent in the second story of the culled than of the virgin forest.

It would seem certain that both of these species were originally very numerous in the area; but, as will be shown later, possibly others were equally prominent. However, as the latter possibility is only a speculation, the culled forest will, for convenience, be placed in the *Parashorea-Diplodiscus* association. To avoid confusion "dipterocarp forest" or "*Parashorea-Diplodiscus* association" will be used only for the virgin portion of the forest, except where the names are modified by "culled" or an equivalent adjective.

The present composition of this forest can be best explained by describing in detail the composition of a selected area. The plot on which measurements were made was at an elevation of about 200 meters and was 50 meters square. It was thus the same size as the plot described in the virgin dipterocarp forest, and its slope and exposure were similar.

In Table XI are given the heights of all erect woody plants on the plot that were more than 1 meter in height. Two, *Anaxagorea luzonensis* and *Tabernaemontana pandacaqui*, are small undergrowth shrubs; while another, *Schizostachyum* sp., is an

* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

erect bamboo, which in this case formed a clump of thirty-five stalks. The remainder may be considered as trees, although a few might properly be classified as large shrubs.

TABLE XI.—*Heights of all trees over 1 meter in height on 0.25 hectare in culled dipterocarp forest on Mount Maquiling; altitude, 200 meters.*

[Figures represent numbers of individuals.]

No.	Species.	Height in meters.											Total.
		1 to 2.	2 to 6.	6 to 10.	10 to 12.	12 to 14.	14 to 18.	18 to 22.	22 to 26.	26 to 30.	30 to 34.	34 to 38.	
	FIRST-STORY SPECIES.												
	Dipterocarps:												
1	*Shorea guiso* (guijo)	1	9	1		1	1						13
2	*Parashorea malaanonan* (bagtican lauan)	26	12	2				1				2	43
3	*Pentacme contorta* (white lauan)	4	12	4	4			1					25
	Miscellaneous species:												
4	*Alphonsea arborea*	1	1										2
5	*Canarium luzonicum* (pili)	1	1										2
6	*Canarium* sp		1										1
7	*Celtis philippensis* (malaicmo)	69	109	23	3	3	2	1		1			211
8	*Cryptocarya* sp								1				1
9	*Dracontomelum dao* (dao)	2											2
10	*Eugenia longiflora*	1											1
11	*Eugenia luzonensis* (malaruhat puti)	1	1										2
12	*Eugenia* sp							1					1
13	*Ficus nervosa*	2	4					1					7
14	*Koordersiodendron pinnatum* (amugis)	1	1										2
15	*Meliosma sylvatica*		1										1
16	*Octomeles sumatrana*							1	1				2
17	*Palaquium merrillii*	2		1				1					4
18	*Palaquium tenuipetiolatum* (palac palac)		3										3
19	*Palaquium* sp	1	1										2
20	*Planchonia spectabilis* (lamog)		1	1									2
21	*Pometia pinnata* (malugay)		1		1								2
22	*Pterocymbium tinctorium* (taluto)		2	2	2			1					7
23	*Sterculia crassiramea*	1	1										2
24	*Terminalia edulis* (calumpit)	2											2
25	*Terminalia nitens*		1										1
26	*Urandra luzoniensis* (tapulao)		1										1

TABLE XI.—*Heights of all trees over 1 meter in height on 0.25 hectare in culled dipterocarp forest on Mount Maquiling; altitude, 200 meters*—Ctd.

No.	Species.	Height in meters.											Total.
		1 to 2.	2 to 6.	6 to 10.	10 to 12.	12 to 14.	14 to 18.	18 to 22.	22 to 26.	26 to 30.	30 to 34.	34 to 38.	
	SECOND-STORY SPECIES.												
27	*Aglaia diffusa* (salaquin pula)	7	1										8
28	*Aglaia harmsiana* (malasaging)	2	1	2									5
29	*Aglaia* sp	7	10	2	2								21
30	*Aglaia iloilo*	2	9	3									14
31	*Aglaia llanosiana*			1		1							2
32	*Ahernia glandulosa*		2										2
33	*Alangium longiflorum*			1									1
34	*Alangium meyeri* (putian)	1	2										3
35	*Allophylus grossedentatus*			1									1
36	*Amoora cumingiana*		1										1
37	*Antidesma pleuricum*		3	1									4
38	*Ardisia boissieri* (tagpo)	3	1										4
39	*Ardisia serrata*	1	1										2
40	*Arenga pinnata* (cabo negro)		2		2								4
41	*Artocarpus rubrovenia* (anubing)		1										1
42	*Artocarpus woodii*					1							1
43	*Barringtonia* sp		1										1
44	*Bridelia minutiflora*			1									1
45	*Buchanania arborescens* (balinghasay)	1											1
46	*Canarium ahernianum*			1									1
47	*Canarium lucidum*		1										1
48	*Caryota* sp. (pugahan)				1								1
49	*Chisocheton* sp. (salaquing pula)	1	3	2		1	1						8
50	*Cratoxylon celebicum* (guyong-guyong)		2										2
51	*Cyclostemon maquilingensis* (tinaan pantai)		2										2
52	*Cyclostemon* sp			1									1
53	*Dillenia philippinensis* (catmon)	2			1	1							4
54	*Dillenia reifferscheidia* (catmon)		1										1
55	*Dimorphocalyx longipes*	2	1	1									4
56	*Dimorphocalyx luzoniensis*		1	1									2
57	*Diospyros ahernii* (anang)					1							1
58	*Diospyros pilosanthera* (bolongeta)	2	2	2									6
59	*Diplodiscus paniculatus* (balobo)	14	28	11	1	2	2	2					60
60	*Dysoxylum pauciflorum*	2	4										6
61	*Dysoxylum rubrum*	2	1										3
62	*Euonymus javanica*	1	2										3

TABLE XI.—*Heights of all trees over 1 meter in height on 0.25 hectare in culled dipterocarp forest on Mount Maquiling; altitude, 200 meters*—Ctd.

No.	Species.	Height in meters.											Total.
		1 to 2.	2 to 6.	6 to 10.	10 to 12.	12 to 14.	14 to 18.	18 to 22.	22 to 26.	26 to 30.	30 to 34.	34 to 38.	
	SECOND-STORY SPECIES—continued.												
63	*Euonymus viburnifolia*		1										1
64	*Euphoria cinerea* (alupag)		1		1								2
65	*Evodia glabra*		1				1						2
66	*Evodia villamilii*							4					4
67	*Ficus ampelos* (malaisis)		2		1								3
68	*Ficus barnesii*	5				1							6
69	*Ficus linearifolia*		1										1
70	*Ficus minahassae* (hagimit)							1					1
71	*Ficus satterthwaitei*				1								1
72	*Ficus* sp		1				1						2
73	*Ficus* sp			1									1
74	*Garcinia venulosa* (gatásan)	2	1										3
75	*Goniothalamus amuyon*		1										1
76	*Goniothalamus elmeri*						1						1
77	Indt	4			1								5
78	*Knema glomerata* (tambalao)	20	15	3									38
79	*Mallotus ricinoides* (hinlaumo)							1					1
80	*Myristica philippensis* (duguan)		1		1								2
81	*Nephelium mutabile* (bulala)	11	1				1						13
82	*Oroxylum indicum* (pincapincahan)		1										1
83	*Osmelia conferta*	2	6			1							9
84	*Osmelia philippinensis*		1	1	3	1	1						7
85	*Pisonia umbellifera* (anuling)		1			1							2
86	*Polyalthia cumingiana*	3	1										4
87	*Polyalthia* sp	4	7										11
88	*Pterospermum diversifolium* (boyek)	20	9	5	4	3	2						43
89	*Pygeum preslii* (uto-uto)		1	1									2
90	*Quercus soleriana* (cataban)		1										1
91	*Quercus* sp		1										1
92	*Nauclea orientalis* (bancal)		1										1
93	*Schizostachyum* sp (boho)						1						1
94	*Semecarpus philippinensis* (ligas)	1											1
95	*Sideroxylon* sp. (white nato)		2		1	1							4
96	*Sterculia oblongata* (malacacao)		1										1

TABLE XI.—*Heights of all trees over 1 meter in height on 0.25 hectare in culled dipterocarp forest on Mount Maquiling; altitude, 200 meters*—Ctd.

No.	Species.	Height in meters.											Total.
		1 to 2.	2 to 6.	6 to 10.	10 to 12.	12 to 14.	14 to 18.	18 to 22.	22 to 26.	26 to 30.	30 to 34.	34 to 38.	
	SECOND-STORY SPECIES—continued.												
97	*Strombosia philippinensis* (tamayuan)	36	35	2			1						74
98	*Symplocos villarii*		1										1
99	*Symplocos* sp			1									1
	THIRD-STORY SPECIES.												
100	*Callicarpa erioclona* (palis)	2	11										13
101	*Canarium villosum* (pagsahing)		1										1
102	*Casearia* sp. (malatapai)	11											11
103	*Citrus hystrix* (cabuyao)	2		1									3
104	*Cleidion javanicum*		1										1
105	*Clerodendron quadriloculare*	1	1										2
106	*Croton consanguineus*		1										1
107	*Ficus manilensis* (isis)		1			1							2
108	*Glochidion album* (magna)		2										2
109	*Glochidion philippicum*		2										2
110	*Glochidion reticulatum*		1										1
111	*Glochidion* sp	1											1
112	*Grewia stylocarpa* (susumbic)	1	1	1									3
113	*Ixora longistipula*		3										3
114	*Leea manillensis*	5	1		1								7
115	*Leea philippinensis*	1	1										2
116	*Lepisanthes schizolepis*		2										2
117	*Leucosyke capitellata*					1							1
118	*Litsea luzonica*		1										1
119	*Macaranga bicolor* (hamindang)	1	1			1							3
120	*Macaranga grandifolia* (taquip asin)			3									3
121	*Neotrewia cumingii* (batobato)	4	3		2								9
122	*Papualthia lanceolata* (lanutan)	12	1										13
123	*Pithecolobium subacutum*					1							1
124	*Psychotria* sp	1	1										2
125	*Siphonodon celastrineus*	1	1										2
126	*Sterculia cuneata*	1											1
127	*Voacanga globosa* (bayagusa)	2	1										3
	UNDERGROWTH SPECIES.												
128	*Anaxagorea luzonensis*	12											12
129	*Tabernaemontana pandacaqui* (pandacaqui)	1											1
	Total	332	379	84	33	23	15	16	2	1	0	2	887

In the table are listed 129 species. Of these only 29 are found in the table for the plot in the virgin dipterocarp forest. This difference in specific composition was due partly to differences in elevation, some species in the dipterocarp forest being characteristic of higher and others of lower elevations.

The removal by logging of a large part of the main canopy favored the development of certain species, but did not cause the appearance of any that do not normally occur in the dipterocarp forest. Species that are aided by logging are more likely to be found on a limited plot in a culled than in a virgin forest, while the reverse is the case with species upon which the effect of cutting is injurious. The disappearance of most of the large trees resulted in the presence of a much larger number of small individuals and very likely an accompanying greater number of species. It is thus probable that logging caused a considerable change in the species on the plot, but it would seem that its greatest effect was to increase the number of species on a limited area and not to add new ones to the forest.

The differences in the lists of species for the plots in the culled and in the virgin forest are due to a considerable extent to the small size of the plots, and they emphasize the great diversity of species found in the dipterocarp forest. In each case many species are represented by only one individual, and so it is not surprising to find that enlarging the size of the plot would greatly increase the number of species. It is not unusual to find that a species which is fairly numerous in a given area is not represented on a plot as small as those from which the lists were prepared. In classifying the species according to stories, the same heights have been used as in the case of the virgin forest. Most of them belong to the same story in both areas, but a few appear to reach different heights in the two regions. This is probably due to changed conditions in the lower forest.

There were 50 individuals of dipterocarps more than 2 meters in height on the plot in the culled forest, and only 34 on that in the virgin forest. In the culled forest there were 81 dipterocarps over 1 meter high; of these 43 were of *Parashorea malaanonan* (bagtican lauan), 25 of *Pentacme contorta* (white lauan), and 13 of *Shorea guiso* (guijo). The largest trees on the plot were 2 specimens of *Parashorea*, which were more than 37 meters in height. Neither *Shorea* nor *Pentacme* was represented by large individuals, either on the plot or in the general neighborhood; but in both cases there were enough small and medium-sized trees present to indicate that specimens comparable in size with the large ones of *Parashorea* formerly existed on the plot.

After the two large individuals of *Parashorea* the tallest tree

on the plot was a *Celtis philippensis* (malaicmo), 26.64 meters in height. *Celtis philippensis* is a much shorter and smaller species than *Parashorea malaanonan,* and in a virgin forest its crown is usually shaded by such species as the latter. *Celtis* was the most numerous species on the plot, but most of the individuals were very small, only one being tall enough to be in the first story of a virgin forest. Logging has probably made this species more prominent than it was originally, as its wood is considered of very poor quality, and it is one of the last trees to be removed. Owing to its smaller size it is not nearly so prominent as *Parashorea.* An examination of Table XI will show that *Celtis philippensis* is the only first-story species that can compare in numbers with the dipterocarps *Parashorea malaanonan* and *Pentacme contorta.*

Diplodiscus paniculatus (balobo) was the most numerous species within the limits of the second story and was represented by more large individuals than any other species of this story. The most numerous second-story species was *Strombosia philippinensis* (tamayuan), but most of the individuals were small. *Strombosia* has a very durable wood and is much used for posts of houses, so that even medium-sized trees are logged. *Diplodiscus* is of little value and is not removed until the culling is in its last stages. There were 74 individuals of *Strombosia* and 60 of *Diplodiscus,* so that it seems not impossible that originally *Strombosia* was nearly as prominent as *Diplodiscus,* if not equally so. Whitford * found that *Strombosia philippinensis* was the principal second-story tree in the dipterocarp forest occurring at the lowest altitude on Mount Mariveles. This forest, which Whitford called the *Anisoptera-Strombosia* formation, has a composition very different from anything on Mount Maquiling.

Table XI shows that none of the third-story species were numerous on the plot in the culled forest.

The figures in Table XI are summarized in Table XII. In this table the different stories are regarded as being of the same heights as in the virgin forest. Since a large part of the main canopy has been removed, this classification places in the second story many trees that are exposed to full sunlight. There were 5 trees in the first story, 54 in the second, and 496 in the third.

* Whitford, H. N., The vegetation of the Lamao forest reserve, *Phil. Journ. Sci.* (1906), 1, 403.

TABLE XII.—*Summary of the composition of different stories in the culled dipterocarp forest on Mount Maquiling; altitude, 200 meters.*

[Figures represent numbers of individuals.]

Story to which species belong when the individuals are mature.	Stories in which the individuals present were found.			Total.
	First story; height, 22 to 38 meters.	Second story; height, 12 to 22 meters.	Third story; height, 2 to 12 meters.	
First story	5	15	207	227
Second story		35	243	278
Third story		4	46	50
Undergrowth				
Total	5	54	496	555

The number of trees in the second story was exactly the same as that in the second story on the plot in the virgin forest. The number of individuals in the first and the third stories is very different in the two cases. That a large portion of the first story had been removed from the plot in the culled forest is shown by the fact that there were only 5 trees in this story, while there were 16 in the same story in the virgin-forest plot. The disappearance of a large portion of the first story resulted in the entrance of a greater amount of light into the other stories. The effect of this was to increase the number of individuals in the third story. This story contained 496 trees in the culled forest and 283 in the virgin forest. The large number of individuals in the third story is due to an increase in the number of trees of first- and second-story species in this story, as there are fewer individuals of third-story species in the third story of the culled than of the virgin forest. In the latter there were 78 specimens of third-story species, while there were only 46 in the same story in the culled forest. This would indicate that the trees of third-story species could not stand the drier conditions caused by the removal of the first story so well as could those of first- and second-story species. Small individuals of the latter appear to be benefited by having a greater amount of light than they would normally have in a virgin forest. This is in agreement with the conclusions of Brown and Matthews,* who found that dipterocarps in a virgin forest passed through a very long suppression period, during which growth was extremely slow.

* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

The decrease in the number of trees of third-story species in the culled forest is the more striking when we consider that eleven of the twenty-three third-story species on the plot also occur in open country, and that five of them are common in second-growth forests. These species occur normally in a dipterocarp forest. They have not entered the forest on account of the changed conditions. On the plot in the virgin forest there were in the third story eight third-story and two undergrowth species, which are also found in the open country at the base of the mountain.

Table XIII gives the diameter classes of all trees more than 10 centimeters in diameter on the plot in the culled forest. The prominence of *Parashorea malaanonan* and *Diplodiscus paniculatus* is even more pronounced in this table than in Table XI. The largest tree was a *Parashorea* with a diameter of 139 centimeters. No other species showed diameters half as large as this *Parashorea*. The diameters were for the most part small, and medium-sized diameters occurred only in trees that were not valuable for lumber.

TABLE XIII.—*Diameter classes of all trees more than 10 centimeters in diameter on 0.25 hectare in culled dipterocarp forest on Mount Maquiling; altitude, 200 meters.*

[Figures represent numbers of individuals.]

No.	Species.	Diameter class in centimeters.							Total.
		10 to 20.	20 to 30.	30 to 40.	40 to 50.	50 to 60.	70 to 80.	130 to 140.	
	FIRST-STORY SPECIES.								
	Dipterocarps:								
1	*Shorea guiso* (guijo)	1	1						2
2	*Parashorea malaanonan* (bagtican lauan)		1				1	1	3
3	*Pentacme contorta* (white lauan)	5							5
	Miscellaneous species:								
4	*Celtis philippensis* (malaicmo)	3		1	1				5
5	*Cryptocarya* sp			1					1
6	*Eugenia* sp		1						1
7	*Ficus nervosa* (agusus)					1			1
8	*Octomeles sumatrana*	1	1						2
9	*Palaquium merrillii*	1							1
10	*Pterocymbium tinctorium* (taluto)	3							3

TABLE XIII.—*Diameter classes of all trees more than 10 centimeters in diameter on 0.25 hectare in culled dipterocarp forest on Mount Maquiling; altitude, 200 meters*—Continued.

No.	Species.	Diameter class in centimeters.							Total.
		10 to 20.	20 to 30.	30 to 40.	40 to 50.	50 to 60.	70 to 80.	130 to 140.	
	SECOND-STORY SPECIES.								
11	*Aglaia llanosiana* (alupag)	1							1
12	*Alangium longiflorum*	1							1
13	*Allophylus grossedentatus*	1							1
14	*Artocarpus woodii*	1							1
15	*Caryota* sp. (pugahan)	1							1
16	*Chisocheton* sp. (salaquing pula)		1						1
17	*Cyclostemon* sp	1							1
18	*Dillenia philippinensis* (catmon)	1	1						2
19	*Diospyros pilosanthera* (bolong-eta)	1	1						2
20	*Diplodiscus paniculatus* (balobo)	5	1	1	1				8
21	*Evodia glabra*	1							1
22	*Evodia villamilii*	1	1	1					3
23	*Ficus ampelos* (malaisis)	1							1
24	*Ficus barnesii*	1							1
25	*Ficus minahassae* (hagimit)				1				1
26	*Ficus* sp			1					1
27	*Ficus satterthwaitei*		1						1
28	*Goniothalamus elmeri*		1						1
29	Indt		1						1
30	*Mallotus ricinoides* (hinlaumo)	1							1
31	*Myristica philippensis* (duguan)	1							1
32	*Nephelium mutabile* (bulala)	1							1
33	*Osmelia conferta* (malatapai)	1							1
34	*Osmelia philippinensis*	5							5
35	*Pisonia umbellifera* (anuling)		1						1
36	*Pterospermum diversifolium* (boyek)	5							5
37	*Sideroxylon* sp. (white nato)	1							1
38	*Strombosia philippinensis* (tamayuan)		1						1
	THIRD-STORY SPECIES.								
39	*Ficus manilensis* (isis)			1					1
40	*Leucosyke capitellata*	1							1
41	*Macaranga bicolor* (hamindang)	1							1
42	*Pithecolobium subacutum*		1						1
	Total	48	15	6	3	1	1	1	75

Table XIV gives the volume of all trees more than 10 centimeters in diameter. *Parashorea malaanonan* is more prominent in this than in the preceding tables. This species contained 31.79 cubic meters out of a total volume of 47.72 cubic meters. Table XIV also emphasizes the small size of the other trees, the species next in volume being *Celtis philippensis,* which contained only 2.45 cubic meters, distributed among five individuals.

TABLE XIV.—*Volume of all trees more than 10 centimeters in diameter on 0.25 hectare in culled dipterocarp forest on Mount Maquiling; altitude, 200 meters.*

No.	Species.	Volume in cubic meters.			
		First story.	Second story.	Third story.	Total.
	FIRST-STORY SPECIES.				
	Dipterocarps:				
1	*Shorea guiso* (guijo)	----------	0.47	----------	0.47
2	*Parashorea malaanonan* (bagtican lauan)	31.12	0.67	----------	31.79
3	*Pentacme contorta* (white lauan)	----------	0.07	0.04	0.11
	Miscellaneous species:				
4	*Celtis philippensis*	1.43	0.96	0.06	2.45
5	*Cryptocarya* sp	1.29	----------	----------	1.29
6	*Eugenia* sp	----------	0.41	----------	0.41
7	*Ficus nervosa* (agusus)	----------	0.35	----------	0.35
8	*Octomeles sumatrana*	0.21	0.19	----------	0.40
9	*Palaquium merrillii*	----------	0.08	----------	0.08
10	*Pterocymbium tinctorium* (taluto)	----------	0.10	0.09	0.19
	SECOND-STORY SPECIES.				
11	*Aglaia llanosiana* (alupag)	----------	0.05	----------	0.05
12	*Allophylus grossedentatus*	----------	----------	0.03	0.03
13	*Artocarpus woodii*	----------	0.02	----------	0.02
14	*Chisocheton* sp. (salaquing pula)	----------	0.39	----------	0.39
15	*Dillenia philippinensis* (catmon)	----------	0.12	0.07	0.19
16	*Diospyros pilosanthera* (bolongeta)	----------	----------	0.39	0.39
17	*Diplodiscus paniculatus* (balobo)	----------	2.30	0.03	2.33
18	*Evodia glabra*	----------	0.11	----------	0.11
19	*Evodia villamilii*	----------	1.57	----------	1.57
20	*Ficus ampelos*	----------	----------	0.06	0.06
21	*Ficus barnesii*	----------	0.06	----------	0.06
22	*Ficus minahassae* (hagimit)	----------	1.25	----------	1.25
23	*Ficus satterthwaitei*	----------	----------	0.19	0.19
24	*Ficus* sp	----------	0.52	----------	0.52
25	*Goniothalamus elmeri*	----------	0.49	----------	0.49
26	Indt	----------	0.27	----------	0.27
27	*Mallotus ricinoides* (hinlaumo)	----------	0.16	----------	0.16
28	*Myristica philippensis* (duguan)	----------	----------	0.12	0.12
29	*Nephelium mutabile* (bulala)	----------	0.11	----------	0.11
30	*Osmelia conferta* (malatapai)	----------	0.03	----------	0.03
31	*Osmelia philippinensis*	----------	0.07	0.15	0.22
32	*Pisonia umbellifera* (anuling)	----------	0.19	----------	0.19
33	*Pterospermum diversifolium* (boyek)	----------	0.24	----------	0.24
34	*Sideroxylon* sp. (white nato)	----------	0.06	----------	0.06
35	*Strombosia philippinensis* (tamayuan)	----------	0.37	----------	0.37
	THIRD-STORY SPECIES.				
36	*Ficus manilensis* (isis)	----------	0.57	----------	0.57
37	*Leucosyke capitellata*	----------	0.15	----------	0.15
38	*Macaranga bicolor* (hamindang)	----------	0.03	----------	0.03
39	*Pithecolobium subacutum*	----------	0.01	----------	0.01
	Total	34.05	12.44	1.23	47.72

The results given in Table XIV are summarized according to stories in Table XV. Owing to the huge bulk of the large individuals of *Parashorea* a great part of the volume was in the first-story species in the first story. The volume of the first story was only 38 per cent lower than that of the same story in the virgin forest. The comparatively high volume of the culled forest was due to the presence of a single, very large *Parashorea*. The second and third stories in the culled forest showed relatively greater decreases in volume than the first story. The loss in the second story was probably due to the logging of the more valuable specimens, while that in the third was incidental to the removal of large trees or was the result of changed conditions.

TABLE XV.—*Summary of composition by volume of the different stories in culled dipterocarp forest on Mount Maquiling; altitude, 200 meters.*

Stories to which species belong when the individuals are mature.	Stories in which individuals present were found.			Total.
	First story; height, 22 to 38 meters.	Second story; height, 12 to 22 meters.	Third story; height, 2 to 12 meters.	
First story	34.05	3.30	0.19	37.54
Second story		8.38	1.04	9.42
Third story		0.76		0.76
Total	34.05	12.44	1.23	47.72

The plot just discussed is evidently a reduction product from a typical dipterocarp forest. The same species are present, but the individuals are smaller and more numerous. Probably the chief difference in specific composition, which has resulted from culling, is that the removal of the best individuals of the most valuable species has favored the less valuable ones.

In the plot just described an area 10 meters square was selected before it had been disturbed, and all plants less than a meter in height were counted, the results being given in Table XVI. There were 112 plants less than a meter in height on the plot. The majority of them, 62, were of tree species, 46 were herbs, and 4 were vines. The total number was small when compared with the 427 on the similar plot in the virgin forest.

TABLE XVI.—*Plants less than 1 meter in height on plot 10 meters square in culled dipterocarp forest on Mount Maquiling; altitude, 200 meters.*

No.	Species.	Number of plants.
	TREES.	
1	*Aglaia iloilo*	2
2	*Aglaia diffusa*	1
3	*Casearia* sp	1
4	*Celtis philippensis*	15
5	*Cyclostemon maquilingensis*	1
6	*Dysoxylum* sp	1
7	*Euonymos javanica*	1
8	*Ficus linearifolia*	1
9	Indt	1
10	*Lepisanthes schizolepis*	1
11	*Palaquium* sp	1
12	*Papualthia lanceolata*	1
13	*Parashorea malaanonan*	1
14	*Pentacme contorta*	2
15	*Pithecolobium subacutum*	15
16	*Polyalthia* sp	2
17	*Sterculia crassiramea*	1
18	*Strombosia philippinensis*	11
19	*Symplocos* sp	1
20	*Terminalia nitens*	2
	HERBS.	
21	*Alpinia brevilabris*	11
22	*Chloranthus officinalis*	23
23	*Donax cannaeformis*	12
	VINES.	
24	*Calamus* and *Daemonorops*	4
	Total	112

Vines are very prominent in the culled forest. The most conspicuous are climbing bamboos, especially *Schizostachyum diffusum.* Besides these there are climbing palms (rattans) and a large number of dicotyledonous vines. The increase in light in the lower stories, due to the removal of the large trees, causes such an increased development of climbing bamboos that they are very important factors in giving character to the appearance of the vegetation. Owing to the small size of most of the trees and the great development of vines, the culled forest presents the appearance of a low dense tangle.

The ground covering consists largely of woody plants, for the most part seedlings of trees and vines. Among the commonest shrubs are *Anaxagorea luzonensis* and *Tabernaemontana pandacaqui.* Except in ravines herbaceous species are scarce, and those that do occur on the ridges are adapted to withstand fairly dry conditions.

Having considered the present composition of the culled forest, we are now in a position to form an idea of the type of forest that originally occurred on the lower slopes of Mount Maquiling. Judging from the size of the large individuals of *Parashorea malaanonan* that are left and the number of seedlings and small specimens of other dipterocarps, the original forest at elevations of about 200 meters must have been pronouncedly dipterocarp. Its average height must also have been greater than that of the more nearly virgin dipterocarp forest at higher elevations.

This forest probably extended below the region in which we now find the grassland and the second-growth forest previously described. At these elevations occasional large individuals of *Parashorea malaanonan* and smaller trees of other dipterocarp species occur along the streams.

OPENINGS IN DIPTEROCARP FOREST

The first stages of the successions that occur in openings appear to be quite uniform. If the opening is a small one, such as is caused by the fall of a large tree, the first tree species to enter is usually *Macaranga bicolor*. Accompanying it at low elevations is an herbaceous vine, *Trichosanthes quinquangulata,* and at higher altitudes a raspberry, *Rubus fraxinifolius*. These plants grow rapidly, and rattans quickly enter the area, so that the opening is soon filled.

The plot in the virgin forest at an altitude of 450 meters was divided into two parts, after the vegetation had been removed. One part was used for planting experiments, and the other was left bare. The latter part soon became covered with a thick growth consisting almost entirely of the second-growth tree *Trema orientalis.*

Clearings have been made in the forest at low altitudes and then abandoned after little or no cultivation. The early stages of these were not observed, but after four or five years they were covered with second-growth forest composed very largely of *Trema orientalis*. *Trema* appears, therefore, to be the first invader in cleared areas.

On the plot at an elevation of 450 meters *Trema* was not preceded by herbaceous vegetation. A few scattered annuals appeared about the same time as *Trema,* but they were small and not numerous enough to influence the successions and soon disappeared. Brown and Matthews * found that when the dipterocarp forest of northern Negros was removed the ground became covered very quickly with an almost pure stand of *Trema orientalis*. Usually areas from which dipterocarp forests have been removed are invaded by second-growth forests consisting of almost pure stands of a single species, but the species varies in different cases. If the ground is cultivated, the successions are quite different, as has been previously shown.

* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

MIDMOUNTAIN FOREST

The formation above the dipterocarp forest, which from its habitat may be called the midmountain moist-tropical formation, differs from the former not only in composition but also in physical type. It is much less dense than the dipterocarp forest and has only two stories of trees, the taller being about the same height as the second story in the *Parashorea-Diplodiscus* association. From its physical type it may be called an evergreen two-story forest formation.

Its two-story character, rather than its specific composition, has been used as a criterion for determining the limits of the distribution of this formation. It may be regarded as extending from about the 600-meter contour up to an elevation of approximately 900 meters. The most prominent physical characteristics remain fairly constant throughout this area, but the specific composition changes considerably. For convenience the present discussion will be confined to the ridge on which the main trail is located, and where all measurements of environmental factors were made. Neighboring ridges would, of course, be much like the one to be described. As the trees of this formation are small and the region is inaccessible, the forest has remained in practically a virgin condition. Plates XVI to XX, fig. 1, show views in this forest.

The midmountain formation, like the dipterocarp forest, contains many species and is such a mixed type that it is difficult to tell which species predominate, even in a limited area, without making actual counts and measurements of the individuals present.

The main canopy is usually continuous, but is fairly open—much more so than is that of the dipterocarp forest. The height of the canopy varies slightly at different elevations, becoming lower as higher altitudes are reached. At 700 meters it is approximately 18 meters in height, although some of the species are taller than this and some shorter.

The second story is well developed at lower elevations, but less prominent at higher. The species composing it vary considerably in height. Some of them have a maximum height of about 6 meters, while others frequently reach 12 meters or more. The average for this story is probably about 8 meters.

Between elevations of about 600 and 700 meters there is a considerable development of rattans, which are tangled with the second story and the undergrowth. In places this gives the forest a dense appearance. Rattans occur at higher elevations, but they are not a prominent part of the vegetation.

The undergrowth is much less dense than in the dipterocarp forest (see Plates XVI to XVIII). The ground covering consists largely of ferns and other herbaceous plants. The commonest tall herb is *Strobilanthes pluriformis,* while the most numerous small ones are species of *Elatostema.* These frequently form a thick carpet over the ground. Ferns are also prominent.

The most conspicuous change that takes place within the confines of the midmountain formation is an increase in the amount of epiphytic vegetation. At lower elevations in this formation, as in the dipterocarp forest, epiphytes are scarce, except in the crowns of the taller trees. Ferns and mosses on the tree trunks are, however, slightly more numerous than in the dipterocarp forest. In the lower half of the formation, mosses on the trunks of the trees never form more than a thin covering, and this development is reached on only a small proportion of the trees. In the same region orchids also occur to some extent on the trunks of the trees, and at an elevation of about 750 meters they are numerous enough to be rather showy. Here, however, it is the bark of the trees that is prominent in giving character to the appearance of the forest, and not the epiphytic vegetation.

In the upper portion of this formation epiphytic and climbing vegetation is very much more abundant. At elevations greater than 900 meters the trees are so thickly covered with these epiphytic and climbing plants that the bark is largely hidden, and the branches of the trees are frequently loaded with epiphytes. Orchids are numerous, both on the trunks and in the branches. Vines, more particularly species of *Freycinetia,* are very prominent. Not only scandent but also epiphytic vines are conspicuous. Among the latter may be mentioned *Dichrotrichum chorisepalum,* which is very numerous and owing to its long flowering season and showy blooms is very conspicuous. The other most prominent epiphytic vine is *Trichosporum philippinense.* Plate XXI represents the average covering of the tree trunks at an altitude of about 900 meters. The long leaves on the left belong to a *Freycinetia;* the numerous elliptic, serrate ones in the center and on the right are the leaves of *Dichrotrichum chorisepalum.* The vine with smaller, opposite, entire leaves is *Trichosporum philippinense.* Besides the above, there

are several species of ferns, a *Selaginella,* a species of *Piper,* and a number of other plants. Between and among the larger plants is a covering of mosses.

The increased amount of epiphytic vegetation at this altitude represents a transition from the condition in this formation at lower elevations to that in the mossy forest at higher elevations. In the latter situation the trees are, for the most part, densely covered by a growth of mosses and mosslike plants in which grow a great variety of larger epiphytes.

From the above discussion it will be seen that the midmountain forest formation is an evergreen, two-story, rather open forest composed of medium-sized trees representing many species. Between elevations of approximately 600 and 850 meters there appear to be two distinct associations. Changes in environment between the upper and lower limits of this formation are much greater than in the same range of altitude in the dipterocarp forest. This is largely due to the increased cloudiness near the top of the mountain, the lower part of the formation being frequently in the sunlight while the upper part is bathed in clouds.

The midmountain forest is in most places a very greatly mixed type in which no species dominates in any such manner as does *Parashorea* in the dipterocarp forest. It is, therefore, difficult to define the associations. Counts and measurements of all trees over large areas will very likely show other associations than those described from the ridge under discussion.

QUERCUS-NEOLITSEA ASSOCIATION

Between elevations of approximately 600 and 750 meters there appears to be a single type, to which the name *Quercus-Neolitsea* association has been applied. *Quercus soleriana* (cataban) is apparently represented by more individuals than any of the other larger species of dominant trees, while additional species of *Quercus* are also present in considerable numbers. *Cratoxylon celebicum,* another first-story tree, is probably present in greater numbers than *Quercus;* but it is usually smaller, being slightly shorter and having a smaller crown, so that the individuals are not so conspicuously dominant. The three large trees shown in Plate XVI are of this species. Among the other more prominent first-story species are *Neonauclea calycina* (uisac), *Palaquium philippense* (palac palac), *Weinmannia luzoniensis,* and species of *Ficus.*

The canopy of the first story has an average height of about 18 meters. The trees composing it are smaller than in the first

story of the dipterocarp forest, and consequently much more numerous (see Plates XVI and XVIII). In limited areas, such as a fourth of a hectare, there are also more species in the first story of the *Quercus-Neolitsea* association than in the same story in the dipterocarp forest.

Most of the tree species in the *Quercus-Neolitsea* association are also found in the dipterocarp forest. The species common to the two associations and which occur as first-story trees in the *Quercus-Neolitsea* association are usually second-story species in the dipterocarp forest.

The occurrence of these species in the first story in the midmountain forest is probably connected with the smaller amount of light at the higher elevations. These first-story trees are not very different in size from those of the second story in the *Parashorea-Diplodiscus* association. Large specimens frequently grow to be between 20 and 22 meters in height and have diameters of more than 50 centimeters. When species belonging to the first story in the dipterocarp forest are found in the *Quercus-Neolitsea* association, they are much smaller at maturity in the latter than in the former forest.

The second story is composed of numerous small trees belonging to many species. The average height of this story is about 7 meters. Occasional specimens may be more than 14 meters in height, but most of the species are rarely more than 10 and some, such as *Saurauia luzoniensis,* reach a maximum height of about 6 meters. The method of growth of many of the species is quite irregular. Some of the individuals will form straight trees with clear trunks, while others of the same species will branch near the ground, or in other ways form irregular specimens. In Table XVII the height of the tallest individual of *Neolitsea villosa* on a quarter of a hectare is given as 18.55 meters. The main part of the crown of this tree was well within the second story, while a small, slender branch had shot up and entered the first story. Most of the trees are not only short but also slender. In some species, however, individuals with diameters of 30 centimeters or more are not rare.

The most numerous tree species in the association belong to this story. These are *Oreocnide trinervis* (malatuba), *Neolitsea villosa,* and *Saurauia luzoniensis. Oreocnide trinervis* (malatuba) is, apparently, the most numerous in the central part of the association, while near the upper limits it is almost entirely absent. This is a small species, which reaches a height of about 8 or 9 meters and is quite irregular in its branching. It

is comparatively seldom that it has a definite clear trunk. *Neolitsea* is a larger species with a more regular tree form. Individuals with a height of 10 or 12 meters are fairly numerous. The leaves are covered with silky hairs, which give them a striking appearance. Owing to the size and number of the trees and the character of the leaves, this species is the most conspicuous of the tree forms in the association. *Saurauia luzoniensis* is one of the smallest second-story trees and is less prominent than *Oreocnide* or *Neolitsea.* Its maximum height is about 6 meters, and its greatest diameter is about 7 centimeters.

Erect palms are much less numerous than in the *Parashorea-Diplodiscus* association and are represented chiefly by scattered specimens of *Pinanga barnesii.*

Tree ferns, *Cyathea,* are much more prominent. Scattered individuals occur in the upper part of the dipterocarp forest. From this point they gradually increase in numbers as higher elevations are reached, until near the top of the mountain they are more numerous than any other tree species. In the *Quercus-Neolitsea* association they occupy about the same position that erect palms do in the dipterocarp forest. They occur as scattered individuals, which have little effect on the forest except as ornaments.

Dicotyledonous vines are much less prominent than in the *Parashorea-Diplodiscus* association. Climbing palms (rattans) are numerous; and, as the forest is so low that they cannot reach great heights, they are very conspicuous. Their bulk, however, is probably much less than in the dipterocarp forest. They are much more prominent in some spots than in others. Where they are relatively scarce, the main canopy is frequently well developed and the undergrowth very open. When they are numerous, the forest appears to be very dense; but in such places the tree growth is usually much less developed than in spots where they are not conspicuous. The rattans, apparently, grow quickly into the more open places where the main canopy has been disturbed, and are afterwards put at a great disadvantage, as the trees reach large size.

Next to the rattans species of *Freycinetia* (Pandanaceae) are the most conspicuous vines. In many places their long spirally arranged leaves give a characteristic appearance to the vegetation. In Plate XVIII they can be seen very plainly on the trunks of the trees. The trunks and branches of old trees are sometimes almost completely covered with them.

With the exception of small rattans, the ground covering is largely herbaceous. *Strobilanthes pluriformis,* which is frequently from 1 to 2 meters high and occasionally reaches about 4 meters, occurs in large numbers.

Among the smaller herbs *Elatostema viridescens* and *E. carinoi* are the most prominent. These are succulents that in places form a thick carpet over the ground. Ferns are much less numerous, but they are rather conspicuous. *Strobilanthes* and *Elatostema* are alike in having very shallow root systems (see Plates XVI and XVII).

The density of the undergrowth, except where rattans form tangles, is very much less than in the dipterocarp forest, while the ground covering is much better developed. The character of the ground covering is shown in Plates XVI and XVII. The open character of the undergrowth is apparently connected with the decreased light intensity at the higher elevations, and the more prominent ground covering of succulent herbs with moister conditions.

In wet ravines Hymenophyllaceae may be fairly numerous; the most prominent species is *Trichomanes apiifolium.*

Not only are epiphytes more numerous than in the dipterocarp forest, but owing to the smaller size of the trees those in the crowns are decidedly more in evidence. The most striking are species of ferns and orchids large enough to render the individual plants conspicuous. Those in the tops of the trees have a xerophytic appearance, while the species in more-protected situations are sometimes more mesophytic.

Species of ferns are more numerous than in the dipterocarp forest. The most prominent are humus-gathering ones, particularly *Asplenium nidus* (the bird's-nest fern) and *Aglaomorpha meyeniana. Aglaomorpha* has fleshy stems, while the bases of the leaves are modified into humus-gathering pockets. The leaves are large, frequently more than a meter in length, pinnate, and very handsome. *Asplenium nidus* is considerably smaller in the midmountain than in the dipterocarp forest.

Orchids are frequently found on the trunks of the trees. Probably the commonest is *Dendrochilum glumaceum.* The flowers of this species are small, but are crowded in the racemes, which are fairly striking. Showy orchids are very scarce in the midmountain forest.

Dicotyledonous epiphytes are also present; among the most prominent are the vine *Schefflera* and the myrmecophilous genera

Hydnophytum and *Myrmecodia*. These are not conspicuous from the ground, but owing probably to the small size of the trees are more in evidence than in the dipterocarp forest.

Mosses and various mosslike plants are frequently numerous on the trunks of the trees, and these sometimes form a thin layer over considerable areas of bark. Hepatics are often found as epiphytes on leaves in ravines.

Strangling figs occur in this forest, but they are rare. Bizarre plants are not so numerous as in the dipterocarp forest. The saprophytic phanerogams are small and inconspicuous. The most numerous are *Epirixanthes cylindrica* (Polygalaceae) and the blue-flowered *Cotylanthera tenuis* (Gentianaceae). The root parasite *Christisonia wightii* (Orobanchaceae) is slightly larger and grows in small clumps. All of these plants are rare.

At an elevation of approximately 740 meters the ridge to which this description applies is narrow and flat for a short distance. Just beyond this there is a steep ascent. The forest on the flat is well developed and has relatively little undergrowth. A large proportion of the dominant trees belongs to one species, *Astronia pulchra*, which is represented by only a few individuals on other parts of the ridge. The flat is, therefore, quite distinct in composition from the remainder of the *Quercus-Neolitsea* association. It has been included in the latter, however, as the flat is small and the physical character of the vegetation is very similar to that of the well-developed parts of the association.

TRANSITION FROM DIPTEROCARP TO MIDMOUNTAIN FOREST

The change from one association to another is usually gradual and is marked by intermediate conditions. This is likely to be particularly true of such complex associations as those on Mount Maquiling. We have seen that the chief difference between the dipterocarp forest and the *Quercus-Neolitsea* association is that the latter lacks the first story of the former. The first story of the *Quercus-Neolitsea* association is approximately the same height and is composed largely of the same species as the second story in the dipterocarp forest. The disappearance of the first story of the *Parashorea-Diplodiscus* association, as this forest changes into the midmountain type, is gradual. In the well-developed dipterocarp forest it forms a continuous canopy. This gradually becomes more and more open, until these first-story trees occur as scattered individuals only and finally disappear.

No marked change in the composition of the minor elements occurs in this transition zone. In most of the dipterocarp forest the ground is bare and herbs are scarce. In the *Quercus*-

Neolitsea association there is in most places a well-developed ground covering of herbs, of which *Elatostema carinoi* and *E. viridescens* are the most prominent. The change takes place, not in the tension zone between the two associations, but in the upper part of the dipterocarp forest. *Elatostema* begins to be abundant at altitudes of 500 to 550 meters, and frequently covers large areas just as it does in the *Quercus-Neolitsea* association.

Rattans, conspicuous as vines and in the undergrowth in the dipterocarp forest, are very numerous in the lower part of the *Quercus-Neolitsea* association; but they are not prominent in the upper part of this area or at higher elevations. The next most conspicuous vines in both the upper part of the dipterocarp forest and the lower part of the midmountain forest are the same species of *Freycinetia* that are the most prominent vines in the remainder of the midmountain forest.

The development of epiphytes is greater in the *Quercus-Neolitsea* association than in the dipterocarp forest. This is due to the general complex of conditions that causes increased epiphytic vegetation as higher elevations are reached; there is no marked change, either in amount or composition of this vegetation, on the border between the two associations.

The midmountain forest is more open than the dipterocarp forest. This change is also a gradual one and begins in the upper part of the dipterocarp forest.

ASTRONIA ROLFEI ASSOCIATION

The ascent of the ridge, above an elevation of approximately 750 meters, is very steep for a height of about 100 meters. The difference in slope is probably connected with the change that takes place in the type of vegetation at this point. The trees are usually much smaller than in the *Quercus-Neolitsea* association, although some reach about the same heights. Many of them have a tendency to assume a down-hill inclination (see Plate XIX and Plate XX, fig. 1).

The small size of the trees is not due entirely to the general complex of conditions that causes the vegetation to become more and more dwarfed as higher elevations are reached. This is shown by the fact that on more gentle slopes at elevations just above this steep region the trees are larger and the forest has an appearance more like that of the *Quercus-Neolitsea* association. The smaller size of the trees on the steep slopes would seem to be due to the unstable condition of the soil and to the interception by the mountain of a part of the light that would reach vegetation on more even ground. The slanting of the

trees is likewise apparently connected with the effects of erosion combined with a tendency to grow toward the light.

The most numerous trees are species of *Astronia*, particularly *Astronia rolfei*. The forest is, however, a very mixed type. The two-storied arrangement is not as well developed as in the *Quercus-Neolitsea* association. Most of the trees would belong to the second story in the latter. The first story is well represented in patches, but in general is not continuous.

Rattans are not prominent and are usually small. The most conspicuous vines are species of *Freycinetia*.

The forest is an open one. Palms are almost entirely absent; while tree ferns, particularly *Cyathea caudata*, are fairly numerous. The ground covering is herbaceous and very similar to that in the *Quercus-Neolitsea* association. Epiphytes are more numerous. At this and higher elevations the pitcher plant *Nepenthes alata* grows as an epiphytic vine in the crowns of the trees. The insect-catching pitchers of this plant are striking when seen at close range, but it is very difficult to find them among the foliage usually surrounding them.

DESCRIPTION OF PLOT

The plot used for detailed measurements in the midmountain forest was at an elevation of approximately 700 meters. It was the same size, 50 meters square, as the plots in the dipterocarp forest and had a similar slope and exposure. As in the other cases the trees were cut, measured with a tape, and then removed. The results are given in Tables XVII to XXII. In these tables the first story is regarded as being from 14 to 22 meters in height, and the second as being from 2 to 14. This arbitrary division has the advantages and disadvantages that were mentioned in the discussion of the tables for the virgin dipterocarp forest. As in the former case the division is approximately correct.

Table XVII gives the heights of all erect woody plants more than 1 meter high. The total number was 578, distributed in 48 genera and 72 species. Besides these there were 255 erect herbs more than a meter in height. Twelve were of the arborescent aroid *Alocasia macrorrhiza*, and the remainder were *Strobilanthes pluriformis*. The tallest of the latter was 3.85 meters high, while 201 of them were between 1 and 2 meters in height.

TABLE XVII.—*Height of all erect plants over 1 meter high on 0.25 hectare in midmountain forest (Quercus-Neolitsea association) on Mount Maquiling; altitude, 700 meters.*

[** Indicate that the species is also found in the dipterocarp forest; * that the genus but not the species is found in the dipterocarp forest.]

[Figures represent numbers of individuals.]

No.	Species.	Height in meters.						Total.
		1 to 2.	2 to 6.	6 to 10.	10 to 14.	14 to 18.	18 to 22.	
	FIRST-STORY SPECIES.							
1	** *Aglaia harmsiana* (malasaging)	1	2					3
2	** *Amoora cumingiana*	1	1					2
3	** *Antidesma pleuricum*			1				1
4	** *Ardisia boissieri* (tagpo)		1		1			2
5	* *Ardisia* sp		1	2				3
6	** *Bischofia javanica* (tuai)				1		1	2
7	* *Canarium* sp. (isañgjuac)					1		1
8	** *Chisocheton cumingianus* (salaquin-puti)		3					3
9	** *Cinnamomum mercadoi* (calingag)		1					1
10	* *Cratoxylon blancoi*				2			2
11	** *Cratoxylon celebicum* (guyong-guyong)			1	8	13	3	25
12	** *Croton leiophyllus*		1			1		2
13	** *Dysoxylum turczaninowii*		1					1
14	** *Elaeocarpus calomala*					1	1	2
15	** *Eugenia arcuatinervia*			1				1
16	** *Eugenia luzonensis* (malaruhat puti)		3					3
17	* *Eugenia* sp. (malabayabas)		1			1		2
18	* *Ficus garciae*					1	1	2
19	** *Ficus paucinervia* (tangisang biauac)				1	3	2	6
20	** *Ficus variegata* (tangisang biauac)		1		1		1	3
21	** *Grewia stylocarpa* (susumbic)		4	1		1		6
22	** *Litsea garciae*		1					1
23	** *Mastixia philippinensis* (tapulao)		1					1
24	** *Nauclea junghuhnii* (mambog)		3	1	1			5
25	** *Neonauclea calycina* (uisac)		4	1	3	1		9
26	** *Palaquium philippense* (palac palac)		3	3		2		8
27	** *Planchonia spectabilis* (lamog)			1		1		2
28	* *Polyalthia* sp			1				1
29	** *Pometia pinnuta*						1	1
30	** *Quercus robinsonii* (oayan)		2					2
31	** *Quercus soleriana* (cataban)		2	2	2	4	2	12
32	* *Saurauia whitfordii*					1		1
33	** *Symplocos ahernii*		1	2				3
34	** *Terminalia pellucida* (talisay-gubat)			1		1		2
35	** *Weinmannia luzoniensis*			1	1	2	3	7

TABLE XVII.—*Height of all erect plants over 1 meter high on 0.25 hectare in midmountain forest (Quercus-Neolitsea association) on Mount Maquiling; altitude, 700 meters*—Continued.

No.	Species.	Height in meters.						Total.
		1 to 2.	2 to 6.	6 to 10.	10 to 14.	14 to 18.	18 to 22.	
	SECOND-STORY SPECIES.							
36	** *Astronia rolfei* (dungao)		2	3	6	1		12
37	** *Astronia williamsii* (dungao)		3	1				4
38	** *Cyathea caudata*	2	11					13
39	** *Decaspermum paniculatum*				3			3
40	** *Dillenia philippinensis* (catmon)			3	2			5
41	** *Dillenia reifferscheidia* (catmon carabao)			2				2
42	* *Eugenia astronioides*		1					1
43	** *Eugenia calubcob* (calubcob)		2	1				3
44	** *Eugenia crassipes* (calubcob)	12	15					27
45	** *Ficus linearifolia* (auymit)			1				1
46	** *Ficus nota* (tibig)		1					1
47	** *Ficus ribes* (auymit)	2	5	1				8
48	* *Ficus* sp			1				1
49	** *Glochidion album* (magna)		5	1				6
50	** *Glochidion lancifolium*		3					3
51	** *Glochidion merrillii*			1				1
52	** *Glochidion trichogynum* (bogna)	1						1
53	* *Homalanthus fastuosus*		3	5				8
54	Indt		1					1
55	** *Laportea subclausa* (lipa)	1	1					2
56	** *Leea aculeata*		3					3
57	** *Leea manillensis*	1	19	2				22
58	** *Leea philippinensis*		5	1				6
59	* *Leea quadrifida*		15					15
60	** *Leucosyke capitellata* (lagasi)			1				1
61	* *Medinilla astronioides*	1	5					6
62	** *Medinilla venosa*		6					6
63	** *Meliosma sylvatica*		2					2
64	** *Memecylon paniculatum* (culis)	1	5	2				8
65	** *Neolitsea villosa*	3	52	24	7	1	1	88
66	** *Oreocnide trinervis* (malatuba)	5	88	23				116
67	* *Pinanga barnesii*		2					2
68	* *Saurauia luzoniensis*	6	49					55
69	** *Thea montana*	1	8	1				10
70	*Urophyllum banahaense*		3	1				4
71	** *Vernonia lancifolia*				2			2
	SHRUBS.							
72	** *Cyrtandra incisa*	1						1
	Total	39	352	94	41	36	16	578
	HERBS.							
73	*Alocasia macrorrhiza*		12					12
74	*Strobilanthes pluriformis*	201	42					243
	Grand total	240	406	94	41	36	16	833

In Table XVII there are listed 35 first-story species and 36 second-story ones. The total number of species of erect woody plants more than 2 meters high was 70, whereas there were 92 on the plot of equal size in the virgin dipterocarp forest. The smaller number would seem to be the natural result of the adverse conditions that caused the disappearance of the first story of the dipterocarp forest.

The species mentioned in Table XVII that also occur in the dipterocarp forest are marked with two stars; where the genus but not the species has been found in the dipterocarp forest, one star is used.

Many of the species in both types occur only as scattered individuals, so that it is very difficult to determine their distribution. Moreover, only a small proportion of the species is in flower at any one time, so that it is frequently impossible to identify the trees as to the species. Among the ninety-two species on the quarter of a hectare in the dipterocarp forest were one unidentified tree and nineteen others which could not be determined as to the species. This was due in part to the similarity of related species and in part to the present state of our knowledge of many Philippine genera. In such a mixed forest as that on Mount Maquiling it is natural that species new to the mountain are frequently found. Only an intensive study of the flora of Maquiling would make it possible to give anything like an exact discussion of the distribution of the component species. Such a study would be an extensive undertaking and is beyond the limits of the present paper.

Among the first-story species there were 28 that also occur in the dipterocarp forest. There were 4 species that could be identified only as to the genus. All of these genera are represented by a number of species in the dipterocarp forest; and it is probable that these 4 species would have been found to occur in this forest, if they could have been identified as to the species. The remaining 3 species were not seen in the dipterocarp forest, but belong to genera that occur in this formation. These 3 species are relatively rare on Mount Maquiling, but it is probable that one of them, at any rate, *Cratoxylon blancoi,* will be found in the dipterocarp forest. Most of the 28 species known from the dipterocarp forest are common in that formation. There were 13 of them on the plot in the virgin dipterocarp forest and 9 on that in the culled forest. Nineteen of the species were on one of the two plots. The number of species common to the plots in both formations is large, when compared with the number found on both plots in the dipterocarp forest. On

the plot in the culled dipterocarp forest there were 129 species, only 29 of which were identified on the plot in the virgin forest.

Of the 28 species found in the first story on the plot in the midmountain forest and which also occur in the dipterocarp forest, 24 are second-story species in the latter formation, while 4 belong to the first story. The latter are *Bischofia javanica, Eugenia luzonensis, Pometia pinnata,* and *Planchonia spectabilis.*

Table XVII shows that there were 36 second-story species on the plot in the midmountain forest, of which 27 occur in the dipterocarp forest. Seven of the identified species and one of the genera were not observed in the latter formation. One of the remaining species could not be identified, while the other was determined only as to the genus. Of the 27 second-story species that occur also in the dipterocarp forest, 22 are third-story trees in the latter formation, while 5 belong in the second story. These are *Dillenia philippinensis, Dillenia reifferscheidia, Ficus linearifolia, Ficus ribes,* and *Memecylon paniculatum.*

The above figures show that of the identified species on the plot, 90 per cent of the first-story species and 81 per cent of those in the second story occur in the dipterocarp forest. From this it will be seen that the *Quercus-Neolitsea* association is made up largely of species that occur in the dipterocarp forest. Many of the species in the various stories of the latter, however, are not found in the midmountain formation. Moreover, the abundance of a species in the dipterocarp forest apparently affords little indication as to whether or not it will be found at higher elevations. *Parashorea malaanonan* and *Celtis philippensis,* the most numerous species in the first story of the dipterocarp forest, do not occur in the *Quercus-Neolitsea* association. However, *Bischofia javanica, Eugenia luzonensis,* and *Planchonia spectabilis* are common species in the first story of the dipterocarp forest and are also in the *Quercus-Neolitsea* association. *Dillenia philippinensis,* probably the third most numerous species in the second story of the dipterocarp forest, is represented by five individuals on the plot in the midmountain forest and is common throughout this formation, while many other numerous second-story species in the dipterocarp forest do not occur at higher elevations.

The species that occur as first-story trees in both the dipterocarp and midmountain forests have a very different size in the two situations. This change in physical type is evidently due to the environmental conditions that have caused the midmountain formation to be a small forest. What has just been said apparently applies also to the species common to the second

story of both the dipterocarp forest and the *Quercus-Neolitsea* association.

In Table XVIII are shown the greatest heights and diameters attained on the plot by each species, the total volume of each species, and the volume of trees more than 14 meters in height (in the first story) and of trees less than 14 meters in height (in the second story). The figures represent the volume of that part of the trunk that was free from branches. The volume of individuals less than 10 centimeters in diameter was very small and so has been omitted from the table.

TABLE XVIII.—*Stand of erect plants over 1 meter in height on 0. 25 hectare in midmountain forest (Quercus-Neolitsea association) on Mount Maquiling; altitude, 700 meters.*

No.	Species.	Number of individuals.	Greatest height on plot.	Greatest diameter on plot.	Volume.[a] Total.	Volume.[a] Trees 4 to 14 meters in height.	Volume.[a] Trees 14 to 22 meters in height.
	FIRST-STORY SPECIES.		*m.*	*cm.*	*cu. m.*	*cu. m.*	*cu. m.*
1	*Aglaia harmsiana* (malasaging)	3	4.30	3.0			
2	*Amoora cumingiana*	2	5.30	6.0			
3	*Antidesma pleuricum*	1	9.56	20.0	0.06	0.06	
4	*Ardisia boissieri* (tagpo)	2	10.95	11.0	0.06	0.06	
5	*Ardisia* sp	3	7.32	14.0	0.06	0.06	
6	*Bischofia javanica* (tuai)	2	21.76	85.0	6.02	0.14	5.88
7	*Canarium* sp. (isangjuac)	1	17.70	32.5	0.49		0.49
8	*Chisocheton cumingianus* (salaquin-puti)	3	5.74	9.0			
9	*Cinnamomum mercadoi* (calingag)	1	2.45	2.5			
10	*Cratoxylon blancoi*	2	13.33	26.0	0.36	0.36	
11	*Cratoxylon celebicum* (guyong-guyong)	25	20.76	58.0	7.03	0.63	6.40
12	*Croton leiophyllus*	2	15.00	22.0	0.13		0.13
13	*Dysoxylum turczaninowii*	1	2.70	2.0			
14	*Elaeocarpus calomala*	2	19.14	45.0	1.84		1.84
15	*Eugenia arcuatinervia*	1	6.24	6.0			
16	*Eugenia luzonensis* (malaruhat puti)	3	5.06	6.0			
17	*Eugenia* sp. (malabayabas)	2	15.70	45.0	1.02		1.02
18	*Ficus garciae*	2	21.55	45.0	1.98		1.98
19	*Ficus paucinervia* (tangisang biauac)	6	20.03	53.0	3.63		3.63
20	*Ficus variegata* (tangisang biauac)	3	18.55	28.0	0.39	0.05	0.34
21	*Grewia stylocarpa* (susumbic)	6	15.00	25.0	0.19		0.19
22	*Litsea garciae*	1	2.32	2.0			
23	*Mastixia philippinensis* (tapulao)	1	3.80	2.5			
24	*Nauclea junghuhnii* (mambog)	5	13.78	27.0	0.34	0.34	
25	*Neonauclea calycina* (uisac)	9	14.85	17.0	0.26	0.17	0.09
26	*Palaquium philippense* (palac palac)	8	16.30	32.5	0.51		0.51
27	*Planchonia spectabilis* (lamog)	2	16.97	32.0	0.55	0.03	0.52
28	*Polyalthia* sp	1	7.08	14.0	0.04	0.04	
29	*Pometia pinnata*	1	21.80	62.0	1.48		1.48
30	*Quercus robinsonii* (oayan)	2	2.65	2.0			
31	*Quercus soleriana* (cataban)	12	21.68	56.0	6.22	1.47	4.75
32	*Saurauia whitfordii*	1	14.25	45.0	0.44		0.44
33	*Symplocos ahernii*	3	8.27	9.0			

TABLE XVIII.—*Stand of erect plants over 1 meter in height on 0.25 hectare in midmountain forest (Quercus-Neolitsea association) on Mount Maquiling; altitude, 700 meters*—Continued.

No.	Species.	Number of individuals.	Greatest height on plot.	Greatest diameter on plot.	Volume.[a] Total.	Volume.[a] Trees 4 to 14 meters in height.	Volume.[a] Trees 14 to 22 meters in height.
	FIRST-STORY SPECIES—continued.		*m.*	*cm.*	*cu. m.*	*cu. m.*	*cu. m.*
34	*Terminalia pellucida* (talisay-gubat)	2	14.10	19.07	0.12		0.12
35	*Weinmannia luzoniensis*	7	19.00	53.5	2.77	0.12	2.65
	SECOND-STORY SPECIES.						
36	*Astronia rolfei* (dungao)	12	15.11	30.0	1.48	1.21	0.27
37	*Astronia williamsii* (dungao)	4	7.38	8.0			
38	*Cyathea caudata*	13	5.45	11.0			
39	*Decaspermum paniculatum*	3	13.40	18.0	0.21	0.21	
40	*Dillenia philippinensis* (catmon)	5	11.40	20.0	0.32	0.32	
41	*Dillenia reifferscheidia* (catmon carabao)	2	8.90	33.0	0.30	0.30	
42	*Eugenia astronioides*	1	3.00	2.0			
43	*Eugenia calubcob* (calubcob)	3	8.00	13.0			
44	*Eugenia crassipes* (calubcob)	27	4.27	5.5			
45	*Ficus linearifolia* (auymit)	1	7.03	15.0			
46	*Ficus nota* (tibig)	1	2.90	4.0			
47	*Ficus ribes* (auymit)	8	7.37	19.0			
48	*Ficus* sp	1	6.30	12.0	0.02	0.02	
49	*Glochidion album* (magna)	6	6.14	6.4			
50	*Glochidion lancifolium*	3	2.65	3.0			
51	*Glochidion merrillii*	1	7.31	5.0			
52	*Glochidion trichogynum* (bogna)	1	1.07				
53	*Homalanthus fastuosus*	8	9.56	8.0			
54	Indt	1	3.30	3.5			
55	*Laportea subclausa* (lipa)	2	1.80	3.0			
56	*Leea aculeata*	3	4.80	4.0			
57	*Leea manillensis*	22	6.15	9.0			
58	*Leea philippinensis*	6	7.10	12.5			
59	*Leea quadrifida*	15	5.10	7.0			
60	*Leucosyke capitellata* (lagasi)	1	7.01	14.0			
61	*Medinilla astronioides*	6	3.82	6.0			
62	*Medinilla venosa*	6	3.82	6.0			
63	*Meliosma sylvatica*	2	5.42	4.5			
64	*Memecylon paniculatum* (culis)	8	6.65	9.0			
65	*Neolitsea villosa*	88	18.55	30.0	1.87	1.32	0.55
63	*Oreocnide trinervis* (malatuba)	116	8.60	18.0	0.05	0.05	
67	*Pinanga barnesii*	2	5.80	6.0			
68	*Saurauia luzoniensis*	55	5.40	8.0			
69	*Thea montana*	10	6.27	17.0	0.09	0.09	
70	*Urophyllum banahaense*	4	6.72	8.0			
71	*Vernonia lancifolia*	2	12.36	41.0	0.80	0.80	
	SHRUBS.						
72	*Cyrtandra incisa*	1	1.10	1.5			
	Total	578			41.13	7.85	33.28
	HERBS.						
73	*Alocasia macrorrhiza*	12	2.60	17.0			
74	*Strobilanthes pluriformis*	243	3.85	3.0			
	Total erect plants over 1 meter high	833					

[a] Volume of trees less than 10 centimeters in diameter is omitted.

Table XIX gives a summary of the data presented in Tables XVII and XVIII. From this table it will be seen that there were 52 individuals in the first story, whereas in the second story of the dipterocarp forest there were 54 individuals. This emphasizes the similarity of the first story in the midmountain forest and the second story in the dipterocarp forest. On the plot in the midmountain forest there were 539 individuals more than 2 meters in height as against 353 in the dipterocarp forest.

TABLE XIX.—*Summary of composition of different stories on 0.25 hectare in midmountain forest (Quercus-Neolitsea association) on Mount Maquiling; altitude, 700 meters.*

Story to which species belong when the individuals are mature.	Stories in which individuals present were found.				Total.	
	First story; height, 14 to 22 m.		Second story; height, 2 to 14 m.			
	Trees.	Volume.	Trees.	Volume.	Trees.	Volume.
		cu. m.		*cu. m.*		*cu. m.*
First	49	32.46	77	3.53	126	35.99
Second	3	0.82	410	4.32	413	5.14
Total	52	33.28	487	7.85	539	41.13

The larger number in the midmountain forest is apparently connected with the fact that the tall dominant story of the dipterocarp forest is lacking, so that the lowest story receives more light. In the first story there are 3 individuals belonging to second-story species. One of these is an individual of *Astronia rolfei,* which an examination of Table XVIII shows was just within the limits of the first story. Two were individuals of *Neolitsea villosa,* one of which was also just within the limits of the first story; while the other, which was 18.55 meters in height, had all of its branches except a single, tall, slender one well within the second story. The number of individuals in the second story was 487, or 9.4 times as many as in the first story. In the second story there were 410 individuals of second-story species and 77 of the first story, showing that the second story is made up very largely of second-story species. This condition is very different from that found in the third story on the plot in the dipterocarp forest, where only 27.6 per cent of the total number of individuals in the third story were of third-story species.

An examination of Table XVII shows that the most numerous first-story species was *Cratoxylon celebicum* (guyong-guyong),

with 25 individuals, while the next most numerous was *Quercus soleriana* (cataban), with 12 individuals. The most numerous second-story species was *Oreocnide trinervis* (malatuba), with 116 individuals; the next, *Neolitsea villosa,* with 88 individuals; and the third, *Saurauia luzoniensis,* with 55 individuals. These last three species together were represented by 259 individuals, which were 45 per cent of all erect woody plants more than 1 meter in height. Each of these three species was much more numerous on the plot in the midmountain forest than any species on the plot in the dipterocarp forest. The most numerous species in the latter case was *Parashorea malaanonan,* with 29 individuals more than 2 meters in height; whereas on the plot in the midmountain forest *Oreocnide trinervis* was represented by 111 individuals more than 2 meters in height; *Neolitsea villosa,* by 85; and *Saurauia luzoniensis,* by 49.

Table XIX shows that the total volume on the plot in the midmountain forest was 41.13 cubic meters. As was to be expected this is much smaller than that on the plot in the dipterocarp forest, which was 76.35 cubic meters. The trees showing the greatest volume were *Cratoxylon celebicum,* with 7.3 cubic meters; and *Quercus soleriana,* with 6.22. The total volume of all trees in the first story was 33.28 cubic meters, and in the second story, 7.85 cubic meters. The volume of first-story trees in the first and second stories is 35.99 cubic meters, and of second-story trees, 5.14 cubic meters. A large portion of the volume was of first-story trees in the first story, this being 32.46 cubic meters, or 79 per cent of the total. The average volume of all trees in the first story was 0.64 cubic meter, and of all in the second story more than 10 centimeters in diameter, 0.09 cubic meter. The average volume of trees in the first story is much less than that of first-story trees in the dipterocarp forest, which have an average volume of 3.1 cubic meters, but considerably greater than the average volume of second-story trees in the dipterocarp forest, these having an average volume of 0.46 cubic meter. The average volume of all trees more than 10 centimeters in diameter in the second story is more than three times that of all third-story trees more than 10 centimeters in diameter in the dipterocarp forest. The average volume of first-story trees in the first story was 0.66 cubic meter; of all first-story trees more than 10 centimeters in diameter in the second story, 0.13 cubic meter; and of all second-story trees more than 10 centimeters in diameter in the second story, 0.07 cubic meter. These figures emphasize the difference in the size of trees in the different stories.

TABLE XX.—*Diameter classes of all trees over 10 centimeters in diameter on 0.25 hectare in midmountain forest (Quercus-Neolitsea association) on Mount Maquiling; altitude, 700 meters.*

[Figures represent numbers of individuals.]

No.	Species.	Diameter class in centimeters.								Total.
		10 to 20.	20 to 30.	30 to 40.	40 to 50.	50 to 60.	60 to 70.	70 to 80.	80 to 90.	
	FIRST-STORY SPECIES.									
1	*Antidesma pleuricum*	1								1
2	*Ardisia boissieri* (tagpo)	1								1
3	*Ardisia* sp	1								1
4	*Bischofia javanica* (tuai)	1							1	2
5	*Canarium* sp. (isangjuac)			1						1
6	*Cratoxylon blancoi*	1	1							2
7	*Cratoxylon celebicum*	8	11	3	1	1				24
8	*Croton leiophyllus*		1							1
9	*Elaeocarpus calomala*		1		1					2
10	*Eugenia* sp. (malabayabas)				1					1
11	*Ficus garciae*		1		1					2
12	*Ficus paucinervia* (tangisang biauac)		1	1	2	1				5
13	*Ficus variegata* (tangisang biauac)	1	1							2
14	*Grewia stylocarpa* (susumbic)		1							1
15	*Nauclea junghuhnii* (mambog)		1							1
16	*Neonauclea calycina* (uisac)	4								4
17	*Palaquium philippense* (palac palac)	1		1						2
18	*Planchonia spectabilis* (lamog)	1		1						2
19	*Polyalthia* sp	1								1
20	*Pometia pinnata*						1			1
21	*Quercus soleriana* (cataban)	1	2	2	1	2				8
22	*Saurauia whitfordii*				1					1
23	*Terminalia pellucida* (talisay-gubat)	2								2
24	*Weinmannia luzoniensis*	2	2		2	1				7
	SECOND-STORY SPECIES.									
25	*Astronia rolfei* (auymit)	3	7							10
26	*Decaspermum paniculatum*	3								3
27	*Dillenia philippinensis* (catmon)	4								4
28	*Dillenia reifferscheidia* (catmon carabao)		1	1						2
29	*Eugenia calubcob* (calubcob)	1								1
30	*Ficus linearifolia* (auymit)	1								1
31	*Ficus ribes* (auymit)	1								1
32	*Ficus* sp	1								1
33	*Leea philippinensis*	1								1
34	*Leucosyke capitellata*	1								1
35	*Neolitsea villosa*	18	6							24
36	*Oreocnide trinervis* (malatuba)	10								10
37	*Thea montana*	2								2
38	*Vernonia lancifolia*		1		1					2
	Total	72	38	10	11	5	1	0	1	138

In Table XX is shown the distribution according to diameter classes of 10 centimeters of all trees more than 10 centimeters in diameter. The total number was 138, or 24 per cent of the total of all trees more than 1 meter in height on the plot. These were distributed in 29 genera and 38 species. Seventy-two, or 52 per cent, were between 10 and 20 centimeters in diameter, while only 7, or 5 per cent, were more than 50 centimeters in diameter. These 7 individuals were all first-story species. Only 2 individuals of second-story species were more than 30 centimeters in diameter, while 26 individuals of first-story species had a diameter greater than 30 centimeters. This again shows the difference in size of first- and second-story species.

TABLE XXI.—*Diameter classes of trees more than 10 centimeters in diameter in the different stories on 0.25 hectare in midmountain forest (Quercus-Neolitsea association) on Mount Maquiling; altitude, 700 meters.*

[Figures represent numbers of individuals.]

Story.	Diameter class in centimeters.								
	10 to 20.	20 to 30.	30 to 40.	40 to 50.	50 to 60.	60 to 70.	70 to 80.	80 to 90.	Average.[a]
First	3	23	9	10	4	1		1	34.3
Second	69	15	1	1	1				17.7
Total	72	38	10	11	5	1		1	

[a] The average diameters were calculated from the exact measurements and not from the figures in this table.

In Table XXI is shown the distribution of the diameter classes in the two stories. It will be seen that 69 out of 72 trees between 10 and 20 centimeters in diameter were in the second story. The larger size of the first-story trees is very evident from the figures in the table. The average diameter of the first-story trees was 34.3 centimeters; and of the second, 17.7 centimeters.

Table XXII gives the clear length of all first-story trees in the first story; that is, those between 14 and 22 meters in height. There were 49 of these, and they were distributed in 16 genera and 18 species. Only 2 individuals had clear lengths greater than 14 meters, while 4 had clear lengths of less than 4 meters. This shows very clearly that most of the first-story trees possessed branches that were within the region regarded as belonging to the second story, and that there was consequently a considerable overlapping of stories. This overlapping was, however, not so great as is indicated in the table, as the lowest foliage of the tree is frequently much higher than the origin of the first branches.

TABLE XXII.—*Clear length of first-story trees 14 to 22 meters in height on 0.25 hectare in midmountain forest (Quercus-Neolitsea association), on Mount Maquiling; altitude, 700 meters.*

[Figures represent numbers of individuals.]

No.	Species.	Clear length in meters.						
		2 to 4.	4 to 6.	6 to 8.	8 to 10.	10 to 12.	12 to 14.	14 to 16.
1	*Bischofia javanica* (tuai)						1	
2	*Canarium* sp. (isañgjuac)			1				
3	*Cratoxylon celebicum* (guyong-guyong)	1	4	4	5	2		
4	*Croton leiophyllus*		1					
5	*Elaeocarpus calomala*					1		1
6	*Eugenia* sp. (malabayabas)			1				
7	*Ficus garciae*			1				1
8	*Ficus paucinervia* (tangisang biauac)	1		1	1	1	1	
9	*Ficus variegata* (tangisang biauac)			1				
10	*Grewia stylocarpa* (susumbic)		1					
11	*Neonauclea calycina* (uisac)		1					
12	*Palaquium philippense* (palac palac)		1		1			
13	*Planchonia spectabilis* (lamog)				1			
14	*Pometia pinnata*		1					
15	*Quercus soleriana* (cataban)		1	1	3	1		
16	*Saurauia whitfordii*		1					
17	*Terminalia pellucida* (talisaygubat)			1				
18	*Weinmannia luzoniensis*	2	2	1				
	Total	4	13	12	11	5	2	2

In order to determine the character of the ground covering, a plot 10 meters square was selected within the limits of the plot of 2,500 square meters, and all terrestrial plants on it measured. The ground covering on this plot was approximately average for the forest. The results are given in Table XXIII. The total number of terrestrial plants on the 100 square meters was 1,630, of which 1,565 were less than 1 meter high; 18 were between 1 and 2 meters high; 37 were between 2 and 12 meters high; and 10 were between 12 and 22 meters high. There were present 23 species of trees represented by 122 individuals, of which 94 were less than 1 meter high, and 28 were more than 1 meter high. This would indicate a high mortality among the small individuals. Four of the 23 species are not found in Table XVII, where all individuals more than 1 meter in height on the plot of 2,500 square meters are enumerated. This would seem to show that, if a plot larger than 2,500 square meters had been

used, the number of tree species found on it would have been greatly increased. No shrubs were found on the area.

TABLE XXIII.—*Composition of plot 10 meters square in midmountain forest formation on Mount Maquiling; altitude, 700 meters.*

[Figures represent numbers of individuals.]

No.	Species.	Height in meters. 0 to 1.	1 to 2.	2 to 12.	12 to 22.	Total.
	TREES.					
1	*Aglaia* sp	1				1
2	*Arenga pinnata*	2				2
3	*Astronia rolfei*			1		1
4	*Cratoxylon celebicum*			1	3	4
5	*Cyathea caudata*	12	1		3	16
6	*Elaeocarpus calomala*	2				2
7	*Eugenia* sp			1		1
8	*Eugenia arcuatinervia*	2				2
9	*Eugenia luzonensis*	2				2
10	*Eugenia mananquil*	17				17
11	*Ficus ribes*				2	2
12	*Litsea* sp	2				2
13	*Memecylon paniculatum*			1		1
14	*Neonauclea calycina*			1	1	2
15	*Neolitsea villosa*	34	1	4		39
16	*Oreocnide trinervis*			2		2
17	*Pinanga barnesii*	14				14
18	*Saurauia luzoniensis*	3		3		6
19	*Symplocos ahernii*	1				1
20	*Terminalia* sp	1				1
21	*Turpinia pomifera*	1				1
22	*Urophyllum banahaense*			2		2
23	*Weinmannia luzoniensis*				1	1
	Total	94	2	16	10	122
	HERBS.					
24	*Alpinia brevilabris*	10		1		11
25	*Calanthe triplicata*	1				1
26	*Chloranthus officinalis*	46				46
27	*Donax cannaeformis*	5		3		8
28	*Elatostema viridescens*	699				699
29	*Elatostema carinoi*	463				463
30	*Selaginella pennula*	2				2
31	*Strobilanthes pluriformis*	99	5	11		115
	Total	1,325	5	15		1,345
	VINES.					
32	*Calamus* and *Daemonorops* (rattans)	103	8	6		117
33	*Freycinetia robinsonii*	5				5
34	*Freycinetia williamsii*	12				12
35	*Lygodium circinnatum*	2				2
36	*Rourea volubilis*	1				1
37	*Schizostachyum diffusum*	23	3			26
	Total	146	11	6		163
	Total of all species	1,565	18	37	10	1,630

Herbs were represented by 8 species and 1,345 individuals, or 83 per cent of the total. Of these, 1,325 were less than 1 meter in height, and only 20 were more than 1 meter high. By far the most numerous species were *Elatostema viridescens,* with 699 individuals, and *E. carinoi,* with 463 individuals. The next most prominent species was *Strobilanthes pluriformis,* with 99 individuals. All three of these species have shallow root systems and occur only in moist situations.

Of vines there were 6 species and 163 individuals. As in the dipterocarp forest, the most prominent species were *Calamus* and *Daemonorops* (rattans), these being represented by 117 individuals, 103 of which were less than 1 meter in height. The next most prominent species was a climbing bamboo, *Schizostachyum diffusum,* with 26 individuals.

On the plot of 100 square meters in the dipterocarp forest there was a total of 492 individuals, whereas on the same-sized plot in the midmountain forest there were 1,630 individuals, or 3.3 times as many as in the dipterocarp forest. On the 100 square meter plot in the dipterocarp forest there were 427 individuals less than 1 meter in height, or an average of 4.3 plants to the square meter. On the same-sized plot in the midmountain forest there were 1,565 plants of similar height, or an average of 15.6 to the square meter. The difference in the density of the ground covering in the two cases is very apparent upon a comparison of the two areas. The difference in the number of herbs is particularly striking, as there were only 66 on the plot in the dipterocarp forest and 1,345 on that in the midmountain forest. They were not only more numerous in the midmountain forest, but also more mesophytic in appearance. This difference is very evidently connected with the moister condition prevailing in the latter formation.

159549——7

MOSSY FOREST

The top of Mount Maquiling is in the cloud belt, and for a very large portion of the time it is bathed in clouds. Consequently the relative humidity is high and evaporation low. This condition is responsible for many features observed in the forest at the summit of the mountain. This forest is, in many ways, more interesting than any of those at lower elevations. It has been designated the mossy forest because the branches and trunks of the trees are largely covered with mosses and mosslike plants. Plate XXVIII shows a typical view near the summit of the mountain; the epiphytic covering is very evident.

The mossy forest on Mount Maquiling may be called a *Cyathea-Astronia* association, as *Cyathea* and *Astronia* are the two most prominent genera. An exterior view of this forest is shown in Plate XX, fig. 2. It is composed of a single story of low trees. Slightly below the summit the average height of the canopy is about 10 meters, while at the summit it is not more than 6 or 8 meters. The trees have a great tendency to send out aërial roots, a feature which is apparently common to all tree species growing in this situation. This tendency is probably connected with the very moist condition of the atmosphere, and causes the trees to assume very fantastic shapes. A rather extreme case of aërial roots is shown in Plate XXII. These roots frequently develop until they have the appearance of secondary trunks, and in many cases it is impossible to identify the original trunk. Much of the ground is very steep, and in such places trees frequently incline downhill, or even fall to the ground. In either case they usually send out additional roots from the trunks and also from large branches. Such a condition naturally adds to the peculiar appearance of the trees.

The covering of mosslike plants on the trees is usually several centimeters in thickness and may be about 30 centimeters thick. On the smaller branches mosses are the most conspicuous elements in this covering. Here the covering is usually not complete, but occurs rather in isolated bunches which are, however, frequently close to each other. Growing in with the moss are a few species of small xerophytic-appearing orchids, ferns, and some phanerogams. Plate XXIII shows a clump of

moss growing on a branch of a tree. The lower end of the cut branch is seen in the lower left-hand corner of the picture. The branch here is 3 centimeters in diameter. The greatest diameter of the moss on this branch was 27 centimeters. To the right in the picture the grasslike orchid *Dendrochilum glumaceum* is seen growing from the moss. At the upper left is a specimen of *Rhododendron quadrasianum* growing from the moss, while in the center are two species of ferns. *Rhododendron quadrasianum* reaches a height of 2 meters or more and is probably the largest epiphyte in the upper portion of the mossy forest. Plate XXIV shows the connection of a large specimen of *Rhododendron* with the plant on which it is growing. For convenience in photographing, the branch on which the *Rhododendron* was found was cut and placed upright on the earth, and the mosses around the roots of the *Rhododendron* were removed. This branch and the roots of the *Rhododendron* show clearly in the center of the lower part of the picture, while all of the conspicuous small leaves occupying the upper center belong to this plant of *Rhododendron.* Note the mosses growing on the *Rhododendron.* These were naturally somewhat disturbed in removing the plant from its original position.

On the trunks the epiphytes have a much more hygrophilous appearance. Mosses are less conspicuous, their places being taken largely by small filmy ferns and liverworts, while a small species of *Selaginella, S. maquiliensis,* is very abundant. Growing in with these are larger filmy ferns, species of Polypodiaceae, and phanerogamic epiphytes. In shallow ravines medium-sized species of Hymenophyllaceae are very abundant on the trunks and the lower branches of the trees.

Shreve * has shown that in the forest at high altitudes on the Blue Mountains of Jamaica the epiphytes in the tops of the trees are more xerophytic than those lower down. This same condition in the Blue Mountains and on Mount Maquiling is due, in both cases, to the fact that conditions are moister at lower elevations in the forest than in the tops of the trees. Plate XXV shows a tree trunk covered largely with a growth of *Selaginella* and the filmy fern *Trichomanes proliferum.* Plate XXVI shows a covering of mosses and liverworts in which is growing the conspicuous filmy fern *Trichomanes apiifolium.* Plate XXVII shows a growth consisting largely of liverworts and mosses on the small aërial roots of a tree. On the lower branches and on

* Shreve, F., A Montane Rain-forest, *Pub. Carnegie Inst. Washington* (1914), No. 199, 1–110.

the aërial roots liverworts and mosses frequently form festoons. In Plates XXVIII and XXIX is shown a typical covering of liverworts and mosses on the lower portions of trees and on the aërial roots. Bird's-nest ferns occur in the lower part of the mossy forest, but they are smaller than at lower altitudes.

The epiphytic vine *Nepenthes alata* is more abundant than in the upper part of the midmountain forest. It occurs in sufficient numbers to be found easily, but does not form a conspicuous part of the vegetation. This plant is shown in Plate XXX, fig. 1. Strangling figs are found scattered in the lower part of the mossy forest, but are not a prominent element.

Very frequently terrestrial plants are prominent as epiphytes. A very conspicuous case is seen in Plate XXXI. This represents a branch of a tree which is so completely covered by a growth of mosslike plants as to conceal the branch. In the lower left-hand corner of the picture the mossy covering is very evident. Growing in this, and occupying most of the picture, is a growth of *Medinilla myrtiformis* and *M. venosa.* These two species of *Medinilla* are sometimes independent terrestrial shrubs, but are more usually woody vines. Growing among the two species of *Medinilla* shown in the picture, but hidden by them, are two seedlings of different tree species, two species of Polypodiaceae, several large filmy ferns, and *Utricularia rosulata.*

The tree fern *Cyathea* is very common and conspicuous, it being the most numerous tree species in the mossy forest. It grows luxuriantly among the other trees, but its crown is not usually fully exposed to the action of sun and wind. Plate I (frontispiece), shows a group of tree ferns (*Cyathea*) found in a ravine a little below the top of the mountain.

Vines, both epiphytic and terrestrial, are fairly prominent, although represented by comparatively few species. Perhaps the most conspicuous are species of *Freycinetia,* particularly *Freycinetia williamsii.* The habit of this plant is shown very clearly in Plate XXX, fig. 2. A typical view in a region slightly below the top of the mountain is given in Plate XXXII. It will be seen that *Freycinetia* is conspicuous in giving character to the appearance of the vegetation. Another very prominent vine is the coarse climbing fern *Oleandra colubrina.* Species of *Medinilla* are also numerous. *Medinilla multiflora,* with its large clusters of pink flowers, is very conspicuous during its blooming season. Among the other prominent vines are *Trichosporum philippinense, Alyxia monilifera, Dichrotrichum chorisepalum,* and *Hoya odorata.* Climbing palms (rattans) grow in the mossy forest, but are not nearly so prominent as at lower elevations.

The ground covering varies in different situations; but, except in very dark places, it usually consists of a fairly dense herbaceous growth. When a tree sends out a considerable number of large aërial roots and has its crown overgrown with vines and epiphytes, the ground below is very densely shaded and is usually absolutely bare. As in the midmountain forest, the most conspicuous large herb is *Strobilanthes pluriformis*. The smaller herbs which cover the ground consist largely of Polypodiaceae, Hymenophyllaceae, species of *Selaginella* and of *Elatostema*, and *Argostemma wallichii*. In shallow ravines medium-sized species of Hymenophyllaceae frequently form a dense carpet over the ground. The most prominent species of filmy ferns are *Trichomanes apiifolium*, *T. pluma*, *Hymenophyllum javanicum*, and the mosslike *Trichomanes proliferum*. A rather typical ground covering of herbs is shown in Plate XXXIII. Here the most prominent element is *Selaginella*.

The vegetation in the ravines and on the slopes shows some striking differences. In general the trees are taller and the forest much more open in ravines than on ridges, so that in descending through a mossy forest, where there are no trails, it is usually convenient to follow the ravines. Near the top of the mountain the ravines are shallow, but the condition in them is even more hygrophytic than on the ridges. This is accompanied by a greater development of medium-sized filmy ferns on the ground and on the lower part of the trees.

The above description applies particularly to the vegetation around the top of the mountain. At lower elevations the vegetation grades into that of the midmountain forest. In the lower portion of the mossy forest ravines are more developed, and there is an accompanying greater difference in the density of the vegetation in them and on ridges. Plate XXXV shows the density of vegetation in a fairly level area near the lower limits of the mossy forest. The vegetation in a shallow ravine at a slightly higher elevation is shown in Plate XXXIV. The vegetation on the slope at the side of this ravine is shown in Plate XXXVI. The more open character of the vegetation in the ravine is very evident.

Showy flowers are conspicuous in the mossy forest. This is in part due to the fact that the forest is low, and the flowers are not so completely hidden by the foliage as at lower elevations. Owing to the uniformity of conditions the blooming season of most species is moreover very long, lasting in many cases for several months. Among the most striking flowers are those of *Melastoma polyanthum*, *Medinilla multiflora*, and *Dichrotrichum*

chorisepalum. *Melastoma* is a very common tree, and has large pale purple flowers, which are produced in great abundance (see Plate XXXVII, fig. 1). The flowers of *Medinilla* are bright pink, produced in large clusters, and so are very striking. The red clusters of *Dichrotrichum*, an epiphytic vine, are very handsome. All of these species have a long blooming season. *Clethra lancifolia*, one of the commonest species in the forest, has a shorter blooming season. During this season the trees are covered with white flowers that remind one of the species of this genus that are found in the United States. Climbing begonias are fairly abundant and produce very striking displays. Plate XXXVII, fig. 2, shows a branch covered with *Begonia aequata.* Mixed with the *Begonia* are leaves of the epiphytic fern *Elaphoglossum.* *Dendrochilum venustulum,* a common epiphytic orchid, produces racemes of small, delicate, yellow flowers. The blooming season of these is short and, as all of the individuals flower at the same time, they make a very showy display. The ground is frequently spotted with the pretty star-shaped white flowers of *Argostemma wallichii.* Besides the above there are many other plants which produce flowers sufficient in beauty and numbers to add greatly to the attractiveness of the forest.

Owing to the peculiar shapes of the trees, the abundance of tree ferns and epiphytes, and the showy flowers, the mossy forest is very picturesque.

The mossy forest on Mount Maquiling may be regarded as typical of mossy forests in the Philippines, although the character of these forests varies greatly in different places. In some the mosslike covering is composed very largely of true mosses; in others, of liverworts; and in still others, of mosslike filmy ferns. The height and specific composition of the trees also varies greatly. • In many places the irregular growth of the trees is not so conspicuous as on Mount Maquiling.

Mossy forests are usually found at or near the top of a mountain. In some cases they occur at high altitudes, but toward the summit give way to a forest that is much less mossy. On the north slopes of Mount Banahao, on the trail leading from Mahayhay to the summit, there is a conspicuous mossy forest at an elevation of about 1,800 meters; while near the summit, at an elevation of about 2,100 meters, there is a forest in which mosses and mosslike plants are not particularly prominent. Near the summit the forest is a two-story one, the first story being composed of *Podocarpus imbricatus*, and the second, of dicotyledonous trees. Two views in this forest are shown in

Plate XXXIX. Mossy forests appear to be confined to the cloud belt, where the atmosphere is saturated with moisture, or nearly so, during all parts of the year.

From the above discussion it will be seen that mossy forests do not constitute a single homogeneous type. With our present knowledge, however, anything approaching an exact classification of them is impossible.

In the Philippines it is only in mountain regions that we find a luxuriant development of epiphytes, and particularly of the mossy forms characteristic of a mossy forest. How far this condition is true of tropical regions in general is very hard to determine from the available literature. In the first place, it is extremely difficult to estimate the amount of epiphytic vegetation from descriptions, as the terms used are more or less general, and the manner of their use depends to some extent on the past experience of the writer describing the forest. Thus, one coming from a temperate country where there are no epiphytes, and visiting a forest of the midmountain type on Mount Maquiling, would be apt to use some such expression as "the trees were covered with epiphytes" or "were heavily laden with epiphytes," and some writers might even use such expressions in describing a dipterocarp forest, on account of its aërial gardens. Moreover, many writers on tropical vegetation have failed to distinguish between lowland and mountain forests. Thus Warming,* in discussing tropical rain forests, says: "The trees forming the highest story have tall thick trunks which are unbranched up to a height of 40 to 50 meters or more." In the same paragraph and without indicating a difference in the size of the trees he adds: "Trees of the forest situate in the cloud-belt in Java and the Moluccas are enveloped in a soaking mossy felt, which may be thicker than the trunks themselves and imparts to them a peculiar, dark appearance."

In the Philippines the vegetation in the cloud belt is dwarfed, and this is certainly true of the Gedeh in Java. In May, 1917, the writer examined the vegetation of the twin peaks Pangaerango and Gedeh. These form the summits of a large mountain mass on the lower slopes of which is situated the mountain station of Tjibodas. As this region is easily accessible from Buitenzorg, the forests of the mountain are frequently referred to in descriptions of Javan forests. The general character of the vegetation is very similar to that found in the Philippines.

* Warming, Eug., Oecology of Plants. Translated into English by Percy Groom and Isaac Bayley Balfour, Clarendon Press, Oxford (1909).

The forest decreases in height rapidly as higher elevations are reached, until near the summits of the peaks the vegetation is, if anything, more dwarfed than that of Mount Maquiling; and it is only to the dwarfed mossy forest at higher altitudes that the second sentence of the quotation from Warming could apply.

The forest at elevations of from 1,300 to 1,500 meters is comparatively high. Doctor Koorders has examined this forest for tall trees. He measured a specimen of *Altingia excelsa,* which was 49 meters high. This tree was, however, much taller than the average height of the tallest story. In this region the forest contains a greater development of epiphytes than is usual in forests of similar heights in the Philippines, the epiphytic vegetation being similar in amount to that found in the midmountain forest on Mount Maquiling, and therefore much less than that of the mossy forest.

Shreve * gives a very interesting discussion of the forests occurring above 1,370 meters on the Blue Mountains of Jamaica. The general character of the forest would appear to be intermediate between the midmountain and mossy types on Mount Maquiling. On the windward slopes the character of the epiphytic vegetation approaches that of the mossy type, and on the leeward, that of the midmountain forest. This idea, derived from Shreve's data, is in harmony with the recollections of the writer, who visited the Blue Mountains of Jamaica in 1910.

Miss Gibbs † has described types of mossy forest from Mount Kinabalu, in British North Borneo, and the high mountains of Dutch New Guinea.

As mossy forests occur at high altitudes in widely separated regions, it seems not unlikely that they are characteristic of the cloud belt of tropical mountains in general. As will be shown later, a heavy and evenly distributed rainfall does not necessarily result in a thick mossy covering, unless the region is one of frequent fogs or in which the atmosphere is nearly saturated with moisture throughout the year.

DESCRIPTION OF PLOTS

As the trees in the mossy forest are low and the composition of the stand much less complex than in the forests at lower

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* Shreve, F., A Montane Rain-forest, *Pub. Carnegie Inst. Washington* (1914), No. 199.

† Gibbs, L. S., A contribution to the flora and plant formations of Mount Kinabalu and the highlands of Brit. N. Borneo, *Journ. Linn. Soc. Bot.* (1914), 42, 8. Idem, A Contribution to the Phytogeography and Flora of the Arfak Mountains, etc. Dutch N. W. New Guinea. Taylor and Francis, Red Lion Court, Fleet Street, London, July, 1917.

elevations, a different method of determining the composition was adopted in the mossy forest. Instead of cutting the trees the heights were measured by a tape fastened to a pole. Owing to the small size of the trees and the less complex composition, smaller plots were considered sufficient. For convenience measurements were taken on ten separate plots, each 5 meters wide by 10 meters long, so that the total of all plots was 0.05 hectare, or one-fifth of the size of the plots used in the midmountain and dipterocarp forests. The plots were situated just below the summit of the east peak of Mount Maquiling. The heights of all individuals more than 1 meter in height on the 0.05 hectare in the mossy forest are given by species in Table XXIV. It

TABLE XXIV.—*Height of all erect, woody plants more than 1 meter in height on 0.05 hectare in mossy forest at the top of Mount Maquiling; altitude, 1,020 meters.*

[Figures represent numbers of individuals.]

No.	Species.	Height in meters.							Total.
		1 to 2.	2 to 4.	4 to 6.	6 to 8.	8 to 10.	10 to 12.	12 to 14.	
1	*Astronia lagunensis*	11	4	3	4	3			25
2	*Clethra lancifolia*	1	8	13	2				24
3	*Cyathea caudata*	12	16	13	3				44
4	*Elaeocarpus argenteus*			3		1	1		5
5	*Eugenia* sp					1			1
6	*Evodia semecarpifolia*		1	2				1	4
7	*Ficus banahaensis*	1			1		1		3
8	*Ficus warburgii*			1					1
9	*Homalanthus alpinus*			1					1
10	*Ilex foxworthyi*			1					1
11	*Itea maesaefolia*	2	3	5	1				11
12	*Machilus philippinensis*				1	1			2
13	*Melastoma polyanthum*	4	7	5					16
14	*Neolitsea villosa*	2	2	1					5
15	*Rapanea philippinensis*			3	2	1			6
16	*Symplocos floridissima*	1							1
17	*Symplocos merrilliana*	1		6					7
	Total	35	41	57	14	7	2	1	157

will be seen that in all there were 17 species. In order to compare the number of species occurring on an equal area in the mossy, midmountain, and dipterocarp forests, it was necessary to examine a larger area in the mossy forest than that from which the data in Table XXIV were gathered. Such an examination of a much more extensive area than that covered by the plots in the lower formations showed only 4 species not mentioned in Table XXIV. These were *Eurya acuminata, Glochidion williamsii, Ficus validicaudata,* and *Eugenia robertii.* It

may, therefore, be assumed that a plot of 0.25 hectare in the mossy forest would not show more than 21 different species of trees, while in the midmountain forest on a plot of similar size there were 71 species represented by individuals more than 1 meter in height, and in the dipterocarp forest there were 92 species of erect woody plants represented by individuals more than 2 meters in height. Any one or more of several possible causes may have been instrumental in producing a forest of but few species on the top of Mount Maquiling. A reduction in the number of stories from three in the dipterocarp to two in the midmountain and one in the mossy forest might be expected to be accompanied by a decrease in the number of species. However, the number of species in the mossy forest is much less than in either the first or the second story in the midmountain forest; as on the plot of 0.25 hectare in the latter forest there were 35 first-story and 36 second-story species represented by individuals more than 1 meter in height. The unfavorable conditions in the mossy forest, which have resulted in a dwarf vegetation might, however, be expected to be accompanied by a smaller number of species than would be found in more favorable habitats.

Another point to be noted is that the dipterocarp forest on the lower slopes of Mount Maquiling was probably continuous with a wide area of similar forest stretching over the plain. This condition would seem to be very favorable for the dispersal of species, whereas the mossy forest covers only a very limited area and is widely separated from similar types of forest. Of the twenty-one tree species in the mossy forest eight appear as understory trees in the dipterocarp forest, but some of them are found only in the upper portion of the forest. These eight species are *Cyathea caudata, Elaeocarpus argenteus, Eugenia robertii, Machilus philippinensis, Glochidion williamsii, Neolitsea villosa, Symplocos floridissima,* and *S. merrilliana.* With the exception of *Cyathea caudata,* which is found only in the upper limits of the dipterocarp forest, none of the species found in both forests is among the more prominent ones in the mossy forest. When we consider the number of species found in the dipterocarp forest and that only eight of them were seen in a large area in the mossy forest, it will be apparent that conditions in the mossy forest are very unfavorable for species growing in the dipterocarp forest. This, together with the fact that the mossy forest on Mount Maquiling is widely separated from other similar forests, may account in part for the scarcity of species in the mossy forest. The mossy forest on Mount Maquiling is like other mossy forests in the Islands in being composed

of a small number of species. Similar reasons are probably responsible for this condition in all cases. If the plots studied in the mossy forest had been near the lower limits of this formation, the number of species present would have been greater, and more species common to both the dipterocarp and the mossy forests would have been noted.

Although the number of species in the mossy forest is small, the number of individuals is greater per unit of area than in either the midmountain or the dipterocarp forest. On the 0.05 hectare in the mossy forest there were 157 individuals more than 1 meter in height. Assuming that the number would be proportional on a larger area, there would have been 785 on 0.25 hectare as against 577 in the midmountain forest; and of erect woody plants more than 2 meters in height, 610 as against 539 in the midmountain forest and 353 in the dipterocarp forest. The increase in the number of individuals over that found in the midmountain forest, as is the increase in the number in the midmountain over that in the dipterocarp forest, is probably connected with the absence of a high story which shuts out a considerable amount of light from the smaller trees.

In Table XXIV the heights of individuals are classified according to height classes of 2 meters. Those more than 4 meters in height may be regarded as being in the main canopy. There were 81 of these. On a plot of 0.25 hectare we would, therefore, expect to find about 405 individuals, whereas in the midmountain forest there were 52 individuals in the first story, and in the dipterocarp, 16. The increase in the number of dominant trees as higher elevations are reached is evidently connected with their smaller size. Table XXIV shows that of the 157 trees on the area there were only 3 more than 12 meters in height. The most numerous species were *Cyathea caudata,* with 44 individuals; *Astronia lagunensis,* with 25; and *Clethra,* with 24. Although in this table *Clethra* appears to be about as abundant as *Astronia,* at a slightly lower elevation in the mossy forest there are other species of *Astronia,* and here *Astronia* is much more prominent than *Clethra.* For this reason the forest has been designated as the *Cyathea-Astronia* association. No measurements of diameters of trees were taken as, owing to the very irregular branching and the formation of aërial roots, this was impracticable with the largest specimens.

In Table XXV the individual species are arranged according to the plots on which they occurred. It will be seen that *Cyathea* and *Astronia* are the only ones occurring in all of them. However, all of the individuals of the different species are fairly

well distributed in different plots, which would indicate that the species distribution is rather uniform.

TABLE XXV.—*Distribution in plots of 50 square meters of all erect woody plants on 0.05 hectare in mossy forest at the top of Mount Maquiling; altitude, 1,020 meters.*

[Figures represent numbers of individuals.]

No.	Species.	Plot No.										Total.
		1	2	3	4	5	6	7	8	9	10	
1	*Astronia lagunensis*	2	1	5	5	1	1	2	1	3	4	25
2	*Clethra lancifolia*	2	6	3	6		1		2	4		24
3	*Cyathea caudata*	3	4	4	4	5	7	8	2	4	3	44
4	*Elaeocarpus argenteus*		2		2				1			5
5	*Eugenia* sp					1						1
6	*Evodia semecarpifolia*	1	1	1				1				4
7	*Ficus banahaensis*					1	1			1		3
8	*Ficus warburgii*		1									1
9	*Homalanthus alpinus*	1										1
10	*Ilex foxworthyi*									1		1
11	*Itea maesaefolia*	4	2		3					1	1	11
12	*Machilus philippinensis*							1			1	2
13	*Melastoma polyanthum*	8					3	3		2		16
14	*Neolitsea villosa*		3		1						1	5
15	*Rapanea philippinensis*	1	3	1						1		6
16	*Symplocos floridissima*				1							1
17	*Symplocos merrilliana*		4		2					1		7
	Total	22	27	14	24	8	13	15	6	18	10	157

TABLE XXVI.—*Height of all erect woody plants in 10 plots of 50 square meters in mossy forest at the top of Mount Maquiling; altitude, about 1,020 meters.*

[Figures represent numbers of individuals.]

Plot No.	Height in meters.							Total.
	1 to 2.	2 to 4.	4 to 6.	6 to 8.	8 to 10.	10 to 12.	12 to 14.	
1	4	7	10	1				22
2	4	9	14					27
3	5	3	3	2			1	14
4	10	6	6	1	1			24
5	1	4	1		1	1		8
6	3	4	5	1				13
7	6	1	5	3				15
8			4	1		1		6
9		5	7	4	2			18
10	2	2	2	1	3			10
Total	35	41	57	14	7	2	1	157

In Table XXVI the individuals in the different plots are distributed according to height. The number on a plot varied from 6 to 27. It will be seen that in general the plots with a small number of individuals contained more large specimens than those with a large number of individuals. This is due to the fact that the large trees cast such a heavy shade that those under them are at a great disadvantage.

OPENINGS IN THE MOSSY FOREST

Openings in the mossy forest caused by the falling of trees are quickly invaded by a rapidly growing tree (*Homalanthus alpinus*), a raspberry (*Rubus fraxinifolius*), and a coarse fern (*Histopteris incisa*). These soon fill the area completely, but apparently are gradually driven out by the trees of the mature mossy forest.

COMPARISON OF VEGETATION AT DIFFERENT ALTITUDES

In order to compare the vegetation in the dipterocarp, midmountain, and mossy forests the figures for erect woody plants, more than 2 meters in height, given in the tables describing the plots in these different formations are summarized in Table XXVII; and those for plants less than 1 meter in height, in Table XXVIII. From Table XXVII it will be seen that the tallest tree on the plot in the dipterocarp forest was 35.95 meters in height; the tallest on the midmountain plot, 21.8 meters; and the tallest on the mossy forest plot, 12.9 meters. The average height of the first story in the dipterocarp forest was 27.2

TABLE XXVII.—*Comparison of erect woody plants more than 2 meters in height on 0.25 hectare in dipterocarp, midmountain, and mossy forests on Mount Maquiling.*

	Dipterocarp forest; altitude, 450 meters.	Midmountain forest; altitude, 700 meters.	Mossy forest; altitude, 1,020 meters.
Number of stories of trees	3	2	1
Height of tallest tree ... meters	35.95	21.8	12.9
Average height of first-story trees ... do	27.2	17.0	5.9
Average height of second-story trees ... do	16.4	4.2	0.0
Average height of third-story trees ... do	9.8	0.0	0.0
Greatest diameter of trees in first story ... centimeters	96.0	85.0	------
Average diameter of trees in first story ... do	52.9	34.3	------
Average diameter of trees more than 10 cm. in diameter in second story ... centimeters	28.4	17.7	0.0
Average diameter of trees more than 10 cm. in diameter in third story ... centimeters	15.6	0.0	0.0
Total volume ... cubic meters	76.35	41.13	------
Volume of first story ... do	48.95	33.28	------
Volume of second story ... do	25.11	7.85	0.0
Volume of third story ... do	2.29	0.0	0.0
Total species of erect woody plants more than 2 meters in height	92	70	21
Species of first-story trees	22	35	21
Species of second-story trees	43	35	0
Species of third-story trees	27	0	0
Total individuals of woody plants more than 2 meters in height	353	539	610
Trees in first story	16	52	405
Trees in second story	54	487	------
Erect woody plants in third story	283	------	------

TABLE XXVIII.—*Comparison of plants less than 1 meter in height on plots of 100 square meters in dipterocarp and midmountain forests on Mount Maquiling.*

[Figures represent numbers of individuals.]

	Dipterocarp forest.	Midmountain forest.
Species	42	28
Individuals	427	1,565
Tree seedlings:		
Species	24	14
Individuals	151	94
Shrubs:		
Species	1	0
Individuals	1	0
Herbs:		
Species	8	8
Individuals	66	1,325
Vines:		
Species	9	6
Individuals	209	146

meters; in the midmountain, 17 meters; and in the mossy, 5.9 meters. The second story in the dipterocarp forest had an average height of 16.4 meters, and in the midmountain forest, 4.2 meters. The greatest diameter of any tree on the plot in the dipterocarp forest was 96 centimeters, and in the midmountain forest, 85 centimeters. The average diameter of all first-story trees in the dipterocarp forest was 52.9 centimeters, and the average of all first-story trees in the midmountain forest was 34.3 centimeters. The total volume of all trees on the plot in the dipterocarp forest was 76.35 cubic meters, and in the midmountain forest, 41.13 cubic meters. The volume of first-story trees in the dipterocarp forest was 48.95 cubic meters, and in the midmountain forest, 33.28; of the second-story trees in the dipterocarp forest, 25.11 cubic meters, and in the midmountain forest, 7.85 meters. The above figures show clearly that there is a very great reduction in the size of the trees and in the volume of timber as higher elevations are reached. This condition is characteristic of mountains in the Philippines, but the degree of dwarfing varies very greatly at the same altitude on different mountains. Thus the mossy forest at the top of Mount Pauai, at an elevation of 2,450 meters, would appear on casual observation to be composed of larger trees than the midmountain forest of Mount Maquiling. In the Philippines the moist lowlands are usually covered with a tall dipterocarp forest

which gives way at higher elevations to another type, and this in turn gives way to an elfin type, which is usually a mossy forest. The dwarfing of trees as high elevations are reached is, of course, characteristic of all high mountains, and the only striking thing about the dwarfing on Mount Maquiling is the comparatively low elevation at which it occurs.

An examination of Table XXVIII shows that the ground covering on the plot in the dipterocarp forest was composed very largely of seedlings of trees and vines, and in the midmountain forest, of herbs. The ground covering in the mossy forest is also composed largely of herbs. This increase in the number of herbs in the ground covering at higher elevations is also characteristic of mountains in the Philippines. However, in lowland forests, where the environment is moister than in the dipterocarp forest on Mount Maquiling, herbs are more prominent.

In the dipterocarp forest the epiphytic species are mostly phanerogams and large ferns, and these are confined chiefly to the largest branches of the tallest trees, where they form aërial gardens. In the midmountain forest the epiphytes consist of phanerogams and large ferns and also small ferns, liverworts, and mosses. Epiphytes are most prominent on the upper branches of the tall trees; they also occur to a considerable extent on the trunks, but do not form a thick covering on the latter. On the branches of the trees the phanerogams and the larger ferns are the most prominent elements, while mosses and liverworts are more prominent on the trunks.

In the mossy forest liverworts, small ferns, mosses, and a small species of *Selaginella* are the most conspicuous elements among the epiphytes. Phanerogams and medium-sized ferns are, however, also prominent. In this forest the trunks are thickly covered with epiphytes, and epiphytes are also very prominent on the branches of the trees. This increase in epiphytes at higher elevations is also characteristic of mountains in the Philippines; but, like the size of the trees, the development of epiphytes varies greatly at the same altitude on different mountains. Where there is no pronounced dry season, epiphytes are more prominent in the lowland forests than in the dipterocarp forest of Mount Maquiling. On the north side of Mount Banahao, which has an elevation of about 2,100 meters, epiphytes are not nearly so prominent as in the mossy forest of Mount Maquiling except in a limited area at an elevation of about 1,800 meters.

As a basis for a comparison of the formations on Mount Ma-

quiling with those on moist tropical mountains in general, we may quote the following discussion by Schimper:*

The *basal region* of tropical mountains generally has a greater rainfall than have the neighbouring lowlands, and is accordingly covered by formations that, in the latter, occupy moist stations, especially places irrigated by the rivers. Rain-forest is here very widespread and frequently of exceeding luxuriance.

The *montane region* in its lower belts has, at the equator, a still tropical although not equatorial character, but near the two tropics it has from the first a temperate character. The difference between the equatorial rain-forest of the basal region on the one hand, and the tropical forest of the lower montane region on the other, is confined to the systematic composition. In temperate montane formations, on the contrary, *the lower temperature is reflected in purely oecological characteristics in the plant-life and impresses upon the formations the stamp of those of higher latitudes.* Hence in the montane region of moist tropical mountains, sometimes at a less, sometimes at a greater altitude above sea-level, the *tropical rain-forest* is replaced by *temperate rain-forest,* like that with which we have become acquainted in the rainy lowlands of South Japan, New Zealand, and South Chili.

The trees in it are evergreen; they never have plank-buttresses, and they possess a more massive growth, a richer ramification, smaller and thicker leaves than trees in the tropical rain-forest. Lianes are fewer in number and thinner in the stem; epiphytes are much smaller, usually herbaceous, and are represented far more by cryptogams (mosses and ferns) than by phanerogams. The extraordinarily luxuriant development of epiphytic mosses exceeds that of the temperate lowland rain-forest, and is to be attributed to the mists prevailing in the montane region. The presence of many closely allied types of plants in the rain-forest of the montane region of tropical mountains, and of the lowlands of higher latitudes, adds a likeness in their flora to the likeness in their oecology.

The transition from the montane to the *alpine* region is characterized by a reduction in the size of the trees and in the amount of their foliage, which gradually acquires a pronounced xerophilous structure. The stems become shorter and relatively thicker, the branches longer, the entire growth becomes irregular, the characteristic form of elfin-tree is revealed.

To the diminutive elfin-wood there succeeds a *xerophilous belt of shrub,* then *alpine grassland* prevails, except on rocks and gravels where low woody plants establish themselves. The grassland usually assumes the form of *alpine steppe.* It consists of tufts of narrow-leaved grasses, the spaces between which are sometimes bare, sometimes occupied by dwarf-shrubs and perennial herbs, and the occurrence of dwarf-trees invests it sometimes with the stamp of a *brushwood-savannah.* Higher up, on the highest summits, grassland is gradually replaced by *alpine desert.* Here grass appears hardly anywhere except in moist oases; dwarf-shrubs and cushion-plants separated by wide gaps make up the scanty vegetation.

The character of the vegetation on different mountains varies

* Schimper, A. F., Plant-Geography upon a Physiological Basis. Oxford (1903), 721.

so greatly that it is only in a general, broad way that it is possible to compare the formations on different mountains. The dipterocarp forest on Mount Maquiling is a type of Schimper's rain forest.

The midmountain forest is a montane forest and would appear to be somewhat intermediate between Schimper's description of a tropical forest of the lower montane region and a temperate montane forest, although it has more of a tropical than a temperate aspect. The most prominent large tree in the midmountain forest is *Quercus soleriana,* but this does not grow in sufficient numbers to give the forest a temperate-zone character. Vines are prominent elements in giving character to the appearance of the vegetation. By far the most prominent ones are species of *Freycinetia* and climbing palms (rattans). Erect palms also occur in this formation. Plank buttresses and cauliflory, while less prominent than in the dipterocarp forest, are found in the midmountain forest, as are also strangling figs. Phanerogamic epiphytes grow in considerable abundance.

A comparison of the heights and diameters of the first-story trees in the dipterocarp and midmountain forests on Mount Maquiling shows that the relation of height to diameter is approximately the same in both cases. Thus the average height of the first-story trees in the dipterocarp forest is fifty-one times as great as the average diameter, and in the midmountain forest the average height of the first-story trees is fifty times as great as the average diameter.

The ramification of the trees in the midmountain forest does not appear to be greater than in the dipterocarp forest. On the other hand, the midmountain forest has certain characteristics that Schimper ascribes to a temperate montane forest. The leaves of the trees in the midmountain forest are, as will be shown later, smaller than in the dipterocarp forest. Lianes are also probably fewer in number and certainly have thinner stems than in the dipterocarp forest. Epiphytes are likewise smaller, in general, and are represented more by cryptogams than by phanerogams. Thus, on account of its more open condition, the greater development of epiphytic mosses and liverworts, and the lesser development of palms, plank buttresses, and strangling figs, the midmountain forest, though distinctly tropical in character, resembles a temperate forest more closely than does the dipterocarp.

Apparently the mossy forest resembles most closely Schimper's alpine region. The stems of the trees are shorter and relatively thicker than at lower elevations, while their growth is very

irregular and their form characteristically that of elfin trees. This forest also has a tropical rather than a temperate aspect. *Clethra lancifolia* may be regarded as representative of a temperate-zone flora; but, while this tree is abundant, it does not grow in sufficient numbers to give distinctive character to the forest. Vines are also very prominent in the mossy forest; and the most conspicuous ones, such as *Freycinetia,* climbing ferns, species of *Medinilla,* climbing begonias, and members of the Gesneriaceae, are certainly tropical and not temperate forms. Phanerogamous epiphytes are prominent. Small individuals of climbing palms, although not a conspicuous element in the vegetation, are nevertheless numerous, while a small erect palm, *Pinanga barnesii,* occurs at the top of the mountain. Owing to the peculiar shapes of the trees and the great development of epiphytes and vines, the mossy forest is much less like an ordinary temperate forest in appearance than is the dipterocarp forest.

While there is at no elevation on Mount Maquiling a forest with a temperate-zone appearance, such forests do occur in the Philippines. On the high mountain mass of Central Luzon there is a very considerable development of forest, composed of pure stands of *Pinus insularis.** This forest is very open, and the ground is covered with grass, while epiphytes and vines are conspicuously absent. It, therefore, has a temperate-zone aspect. Plate XXXVIII shows a view in this forest. The pine forest appears to have developed as a result of the removal of the original forest; and its continued existence apparently depends upon the action of fire, which sweeps through the grass and destroys the seedlings of broad-leaved trees. The forest on the top of Mount Banahao † has two stories, the first being composed of *Podocarpus imbricatus.* Here again vines are conspicuously absent and epiphytes not prominent enough to give character to the appearance of the vegetation. This forest also has a temperate-zone aspect (see Plate XXXIX).

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* Whitford, H. N., The Forests of the Philippines, *Bull. P. I. Bur. For.* (1911), No. 10.

† Brown, W. H., The rate of growth of Podocarpus imbricatus at the top of Mount Banahao, Luzon, Philippine Islands, *Phil. Journ. Sci., Sec. C* (1917), 12, 317–329.

GROWTH

GENERAL DISCUSSION AND METHODS OF MEASUREMENT

A study of the vegetation at different elevations on Mount Maquiling shows that one of the most conspicuous differences in the types of vegetation is the dwarfing of trees as high elevations are reached. It is quite evident that this dwarfing of trees may be caused by any one of several very different factors. The most obvious are periodical or continuous destruction of certain parts of the trees, a slow rate of growth, or quick maturing and early death.

In considering the effect of environment on the size of vegetation it is important to know which of these three causes is responsible for small size. Examination of the vegetation at different elevations on Mount Maquiling shows that dwarfing is a gradual process and is not connected with a destruction of portions of the trees, except perhaps where they are in very exposed situations. In some very steep places erosion has a tendency to keep the trees small; but, as we have seen, dwarfing is in general independent of this factor. It remains, therefore, to determine whether the dwarfing is connected with slow growth or with a rapid maturing of the trees.

In order to answer this question a number of measurements were made of the diameter growth of trees in the parang, and in the dipterocarp, midmountain, and mossy forests. Measurements of growth were not undertaken on a large scale for the reason that, while the collection of the data here presented was in progress, Dr. E. B. Copeland was preparing material for an extensive discussion of rates of growth of plants in the Philippines and particularly those at Los Baños and on Mount Maquiling. Doctor Copeland's data covered growth in the length of plants; and the data here presented, on growth in diameter, were intended to be merely supplementary. Unforeseen circumstances have prevented the publication of Doctor Copeland's data, but it may be said here that the results obtained by him are in keeping with those here presented.

The object of the measurements made on Mount Maquiling was to determine not only the rates of diameter growth but also the ages of different-sized trees at various elevations. Since

annual rings of growth are not known to occur in the Philippines, the only method of calculating rates of diameter growth or the ages of trees of various diameters is to make successive measurements of the girth of the same trees. These measurements must be made at exactly the same point, for a slight deviation in the height at which they are made may show a considerable difference in the circumference. The method employed was to drive a shingle nail a short distance into the tree, just below the tape, at the time of the first measurement. In most of the trees experimented with, the nail caused no swelling; where swelling did occur, the measurements were discarded. A steel tape, about a centimeter wide, was used in measuring all the trees except a few very small ones, which were measured with a narrower and more flexible steel tape. In using this method it has been found practical to measure accurately the girths of even large trees to the nearest 0.5 millimeter.

While the original measurements were of girth, they have been converted into the more usual form of diameters and are expressed in centimeters. In order that these figures might be presented in a usable form, the trees have been grouped according to species and the individual species placed in diameter classes of either 5 or 10 centimeters. The average rates of growth of the different diameter classes have then been calculated and the results divided into the number of centimeters in the diameter class. In this way we obtain figures representing approximately the number of years it takes the average tree to pass through the different diameter classes. These figures, added together, give numbers that may be taken to represent the ages of trees of different sizes. That is, the average rate of growth of trees in the diameter class of from 0 to 10 centimeters divided into 10 centimeters gives us the age of a 10-centimeter tree. If this figure is added to the quotient obtained by dividing the average rate of growth of trees of the 10- to 20-centimeter diameter class into 10 centimeters, we obtain the age of a tree 20 centimeters in diameter. If now the ages of trees of the different diameter classes be plotted on coördinate paper, we can obtain an approximation of the age of a tree of any diameter.

In this method of measurement there are several sources of error which should be taken into consideration. In the first place trees are apt to show different rates of growth in different years, and in order to secure average records the measurements should extend over a series of years. While this is necessary to enable us to make accurate calculations of the ages of trees,

it is not nearly so important in obtaining a comparison between the rates of growth of trees at different elevations.

Some species have a great tendency to shed their bark in large patches. Measurements of the growth of individuals of such species are liable to be very inaccurate, but this error can be overcome by the use of large numbers of trees. Only one species that shed its bark in noticeable patches was measured on Mount Maquiling. In this case the patches were comparatively small, and sufficient individual measurements were taken to make error from this source negligible. A tree with a rough bark has another disadvantage which is, if anything, more serious than the one just mentioned; that is, the irregularities tend to keep the tape from running straight around the tree and thus make measurements less exact.

Successive measurements from which annual rates of growth are calculated must, of course, be made at the same time of year, as rates of growth may vary in different seasons.

The most serious error in estimating the rate of growth of a tree from successive measurements of girth is due to the fact that the girth of a tree may change due to moisture conditions and independently of growth. Thus, there is a tendency for tree trunks to shrink when evaporation is high, the reason for which appears to be that under such conditions tissues may lose more water than they absorb. This results in tree trunks being smaller during the day than at night. Similar phenomena have been observed in other plant parts. Thus, Darwin * has shown that the growing fruit of *Cucurbita* may gain or lose weight according to the moisture condition of the atmosphere. When diminution in weight or size was proceeding rapidly, the fruit showed a loss of 0.1 gram per minute, while shrinkage occurred at the rate of 0.01 millimeter per minute. Livingston and Brown † have shown that during the course of a day the leaves of a plant may lose a very considerable proportion of their water and regain it at night. Thoday ‡ has found that the area of leaves decreases during the day, while Lloyd § and Brown and

* Darwin, Francis, On the growth of the fruit of Cucurbita, *Ann. Bot.* (1893), 7, 459–487.

† Livingston, B. E., and Brown, W. H., Relation of the daily march of transpiration to variations in the water content of foliage leaves, *Bot. Gaz.* (1912), 53, 309–330.

‡ Thoday, D., Experimental researches on vegetable assimilation and respiration. V. A critical examination of Sachs' method for using increase of dry weight as a measure of carbon dioxide assimilation in leaves, *Proc. Roy. Soc. London* (1909), B, 82, 1–55.

§ *Carnegie Inst. Wash. Year Book* (1916), 15, 58.

Trelease * have shown that this may be true also of the length of stems.

Kraus † has measured the diameter of a number of different trees at various times of the day for a few days at Bombay, Singapore, and at three places in Java—Buitenzorg, Garut, and Tjibodas. In his paper dealing with this subject he does not describe his method of measurement nor state whether his measurements were made in millimeters or centimeters, but says that his method is given in an earlier paper (not available in Manila) dealing with variations in the diameters of trees in temperate countries. From the descriptions of the trees measured his measurements would appear to be in millimeters. The greatest and smallest diameters found by Kraus for individual trees are given in Table XXIX. All of the measurements of Kraus

TABLE XXIX.—*Greatest and smallest diameters recorded by Kraus for the same trees within a few days.*

Locality.	Species.	Greatest diameter.	Least diameter.	Difference.
		mm.	*mm.*	*mm.*
Bombay	*Oreodoxa regia*	109.26	108.36	0.90
Do	*Oreodoxa regia*	122.85	121.83	1.02
Do	*Carica papaya*	97.37	97.00	0.37
Do	*Plumeria acutifolia*	48.29	47.75	0.54
Singapore	*Eriodendron anfractuosum* (kapok)	72.60	71.05	1.55
Do	*Carica papaya*	86.53	85.92	0.61
Buitenzorg	*Areca wendlandiana*	92.29	91.81	0.48
Do	Papaya branch a	72.30	71.70	0.60
Do	Papaya branch b	107.77	106.98	0.79
Garut	*Mangifera indica*	70.75	69.30	1.45
Do	*Eriobotrya japonica*	60.20	59.70	0.50
Do	*Ficus elastica*	131.35	131.17	0.18
Tjibodas	*Castanospermum*	64.20	63.83	0.37
Do	*Nauclea* sp	150.35	149.80	0.55
Do	*Cinchona succirubra*	66.70	65.70	1.00
Do	*Calyptrocalyx spicatus*	119.35	119.10	0.25
Average		92.010	91.313	0.697

give concordant results except in the case of an individual of *Annona muricata*, in the records for which there is very evidently a serious typographical error. The figures for this individual have therefore been omitted from Table XXIX.

* Brown, W. H., and Trelease, S. F., Alternate shrinkage and elongation of growing stems of Cestrum nocturnum, *Phil. Journ. Sci., Sec. C* (1918), 13, 353–360.

† Kraus, G. von, Physiologisches aus den Tropen, *Ann. Jard. Bot. Buitenzorg* (1895), 12, 196–216.

Referring to Table XXIX it will be seen that the average of the greatest changes in diameter of the trees measured by Kraus, with the exception of this *Annona muricata,* was 0.697 millimeter. The difference appears in many cases to have been entirely independent of growth, as frequently the smallest measurements were made later than the largest. In some cases where the largest diameters occur near the end of the period, a portion of the differences between the greatest and smallest diameters may have been due to growth, as the period of measurement frequently covered several days; and, as will be shown later, trees may make an appreciable growth in this length of time.

Derry,* in discussing the tapping of *Hevea brasiliensis,* says:

> From a series of tests and measurements I conclude there can be no doubt that the flow of latex depends entirely on the pressure of water, *and the contraction and expansion of a tree during the course of the day is considerable.* A tree of 3 feet girth at 3 feet from the ground measuring exactly 3 feet at 6 A. M. would by afternoon, according to the brightness of the day, contract to a maximum of 1/2 inch, and by 6 P. M. or soon afterwards expand to early morning measurement. Or, if a ligature be fixed tightly on a tree it can be observed that in the early morning the ligature is fully stretched, and by afternoon, if a bright warm day, is quite slack, or partly so, according to the day, and as the evening advances gradually braces up.

Petch † arrived at very different conclusions concerning girth changes in *Hevea.* He made measurements of the girth of this plant in the early morning, at midday, and in the evening but found no appreciable differences. As he measured his trees only to the nearest millimeter, his measurements might have failed to show changes corresponding to some of the smaller of those observed in other trees by Kraus.

In discussing the results of Derry, Petch makes the following statements:

> The kind of ligature employed has not been recorded, but it may be pointed out that if a piece of string were tied round the stem in the early morning when everything is damp it would naturally become slack, through drying, by midday on a dry day.
>
> * * * In ordinary estate measurements, in which the trees are not measured at a fixed line, but only approximately at a height of 3 feet, it has been found that the possible error is fully half an inch.

Petch made weekly measurements of the girth of *Hevea brasiliensis,* at 9.30 in the morning on the same day of the week,

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* Derry, R., Experimental tapping of para rubber trees at the Botanic Gardens, Singapore, *Agr. Bull. Straits & Fed. Malay States* (1904), **3**, 340.

‡ Petch, T., The girth increment of Hevea brasiliensis, *Ann. Roy. Bot. Gard., Peradeniya* (1916), **6**, 77.

from 1912 to 1914. In the course of these measurements he found a shrinkage during the dry season; but the greatest decrease recorded in nine weeks amounted to only 3 millimeters in girth, and it was never greater than 1 millimeter per week.

In order to determine something of the variations in the girth of tree trunks in the Philippines measurements were made on a number of trees growing at Los Baños, on a sunny day in December. With one exception these were of rapidly growing second-growth species and were scattered in the lawn around the forest station, which was situated at the top of an exposed ridge. They were, therefore, fully exposed to changes in light and wind. These trees would be expected to show greater girth variations than would trees growing in a forest, and particularly in a dense one such as the dipterocarp forest. The exception mentioned was a large individual of *Parashorea malaanonan* (*plicata*), growing at the edge of a ravine; its crown was very fully exposed to the sun and wind.

The measurements were made with a steel tape, and in order that the place of measurement might be located exactly this was indicated by one or more shingle nails driven into the tree. The tape used was a centimeter wide. This width gives the tape considerable stiffness and keeps it from sagging; therefore, measurements made with it, except in the case of very small trees, are much more accurate than those made with a narrower tape. Actual experience has proven that it is possible to measure girth accurately to the nearest 0.5 millimeter. The trees under consideration were measured at two-hour intervals from 8 p. m. on December 12 to 6 p. m. on December 13, except that no measurement was made at 4 a. m. The results are recorded in Table XXX. From this table it will be seen that the greatest average girth for all trees was at 6 a. m., and the least at 12 noon and 2 p. m., and that the average difference in girth between 6 a. m. and 2 p. m. was 1 millimeter. This would indicate clearly that there might be an error of 1 millimeter between measurements of girth made at 6 a. m. and those made at 12 noon. A further examination of Table XXX shows, however, that the greatest average difference in girth between 8 a. m. and 6 p. m. was 0.7 millimeter, and between 10 a. m. and 4 p. m., only 0.2 millimeter; the latter is less than the smallest difference that could be accurately measured by the method employed. It would seem, therefore, that measurements taken during the middle portion of the day, or between 10 a. m. and 4 p. m., should not be subject to any considerable error because of changes in girth that occur during the day.

TABLE XXX.—*Measurements of girth of trees from 8 p. m., December 12, to 6 p. m., December 13, 1913, at the base of Mount Maquiling; altitude, about 80 meters.*

[Numbers give girths in centimeters.]

Species.	8 p. m.	10 p. m.	12 midnight.	2 a. m.	6 a. m.	8 a. m.	10 a. m.	12 noon.	2 p. m.	4 p. m.	6 p. m.
Parashorea malaanonan	358.30	358.30	358.30	358.40	358.40	358.25	358.25	358.25	358.30	358.30	358.30
Carica papaya	44.90	45.00	45.00	45.00	45.00	45.00	44.90	44.90	44.90	44.90	45.00
Do	43.50	43.50	43.50	43.60	43.65	43.50	43.40	43.40	43.40	43.40	43.50
Ficus hauili	44.20	44.25	44.25	44.30	44.25	44.20	44.20	44.20	44.20	44.20	44.25
Bauhinia malabarica	75.60	75.55	75.55	75.60	75.60	75.60	75.50	75.50	75.50	75.50	75.50
Trema orientalis	52.40	52.40	52.40	52.35	52.40	52.40	52.40	52.35	52.35	52.30	52.30
Ficus ulmifolia	24.50	24.50	24.50	24.50	24.60	24.60	24.50	24.50	24.50	24.50	24.55
Litsea perrottetii	44.00	44.10	44.05	44.10	44.15	44.10	44.00	44.00	44.00	44.00	44.05
Psidium guajava	49.20	49.20	49.20	49.25	49.20	49.20	49.10	49.10	49.10	49.20	49.20
Trema orientalis	45.40	45.40	45.40	45.40	45.40	45.40	45.35	45.35	45.35	45.35	45.35
Do	35.75	35.75	35.75	35.75	35.80	35.70	35.70	35.65	35.70	35.70	35.70
Do	81.90	82.00	82.00	82.00	82.00	82.00	81.90	81.90	81.90	81.90	81.90
Cordia myxa	27.40	27.50	27.50	27.50	27.50	27.50	27.40	27.40	27.40	27.45	27.50
Do	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	51.90	51.95	51.95
Do	47.40	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.40	47.50	47.50
Do	46.40	46.40	46.40	46.50	46.50	46.50	46.40	46.40	46.35	46.45	46.45
Do	48.40	48.40	48.35	48.40	48.40	48.40	48.40	48.30	48.30	48.30	48.30
Melochia umbellata	23.75	23.75	23.75	23.75	23.80	23.80	23.75	23.75	23.75	23.75	23.75
Do	22.40	22.50	22.50	22.50	22.50	22.50	22.45	22.40	22.40	22.50	22.50
Average	61.44	61.47	61.47	61.49	61.51	61.48	61.43	61.41	61.41	61.43	61.45

Since trees decrease in girth during the day, it seems reasonable to suppose that during the dry season there would also be a tendency for them to decrease in girth, although this decrease might be more than counterbalanced by the growth occurring at this time. As we have seen, Petch found such a decrease in *Hevea.* At Los Baños periodical measurements of the girth of a number of rapidly growing second-growth trees were taken at intervals of about a month during the dry season of 1913. These measurements with few exceptions showed an increase in girth throughout the dry season.

In order to make the results of the measurements taken at Los Baños and given in Table XXX comparable with those of Kraus, the maximum and minimum girths have been brought together in Table XXXI together with the differences between

TABLE XXXI.—*Greatest and least girth measurements in centimeters made on trees from 8 p. m., December 12, to 6 p. m., December 13, 1913, at the base of Mount Maquiling; altitude, about 80 meters.*

Species.	Girth.		
	Maximum.	Minimum.	Difference.
	cm.	*cm.*	*cm.*
Parashorea malaanonan	358.40	358.25	0.15
Ficus hauili	44.30	44.20	0.10
Carica papaya	45.00	44.90	0.10
Do	43.65	43.40	0.25
Bauhinia malabarica	75.60	75.50	0.10
Trema orientalis	52.40	52.30	0.10
Ficus ulmifolia	24.60	24.50	0.10
Litsea perrottetii	44.15	44.00	0.15
Psidium guajava	49.25	49.10	0.15
Trema orientalis	45.40	45.35	0.05
Do	35.80	35.65	0.15
Do	82.00	81.90	0.10
Cordia myxa	27.50	27.40	0.10
Do	52.00	51.90	0.10
Do	47.50	47.40	0.10
Do	46.50	46.40	0.10
Do	48.40	48.30	0.10
Melochia umbellata	23.80	23.75	0.05
Do	22.50	22.40	0.10
Average	61.51	61.40	0.11

these maximum and minimum girths. In this table it will be seen that the greatest difference, 0.25 centimeter, is shown by a specimen of *Carica papaya,* which is a semiherbaceous small tree. The next greatest difference shown in Table XXXI is 0.15 centimeter. The differences shown in Table XXXI are less

than those given by Kraus, although the individual trees in general are considerably larger. The only species considered in both sets of measurements is *Carica papaya,* of which Kraus measured three individuals while two were measured at Los Baños. The average of the greatest differences in diameter found in *Carica papaya* by Kraus is 0.59 millimeter, while the average for those measured at Los Baños is 0.56 millimeter, the two figures being thus very similar. Since the smaller trees measured by Kraus showed greater differences in girth than the larger ones measured at Los Baños, it would seem that changes in girth might by no means be proportional to the size of the trees concerned, but that the smaller trees containing a larger proportion of soft tissues would show a correspondingly higher percentage of change in diameter. This conclusion is rendered probable by an examination of Table XXXI. In this table are given measurements of five individuals of *Trema orientalis.* It will be noted that the smallest individual shows the greatest change in girth, although it had less than half the girth of the largest. Measurements are also given of five individuals of *Cordia myxa,* the largest of which had nearly twice the girth of the smallest, while the changes in girth were equal in the two cases. Again, by comparing the changes in girth of the large *Parashorea* with the changes of the other trees, it will be seen that the *Parashorea,* with a girth of 358 centimeters, showed no greater change in girth than *Carica papaya,* with a girth of 44 centimeters; *Litsea perrottetii,* with 44; *Psidium guajava,* with 49; or *Trema orientalis,* with 36.

We may now consider the effect that the above discussed shrinkage and expansion of tree trunks may have had on the accuracy of the calculations made from the measurements taken at Los Baños. We have seen that the error due to measuring parang trees at the base of Mount Maquiling at different times of the day amounts to only a small fraction of a millimeter in girth. An examination of the tables giving measurements of yearly growth of second-growth trees will show that such an error is small enough to be considered negligible.

The daily variations in girth in the dipterocarp forest should be much less than in the parang, as moisture conditions in the former are much more uniform than in the open. It does not seem probable, therefore, that in determining the rates of growth of these trees any considerable error can be introduced by diurnal variations in the diameters. In the midmountain and mossy forests evaporation is continually low and humidity high

and uniform, so no considerable swelling and shrinking of tree trunks is to be expected. We may, therefore, conclude that diurnal changes in the dimensions of tree trunks are not the cause of any considerable error in the calculation of the rates of growth of trees on Mount Maquiling. In a later section measurements of seasonal growth will be given, and in these measurements this error may be considerable. This point will be discussed later.

An important error in estimating age from consecutive measurements of trees of different sizes is that, in obtaining averages for the smaller classes, we may use measurements of rates of growth of some trees that will not reach a larger diameter class and that are growing more slowly than the larger trees grew when they were of a smaller size. In general, the smaller the trees measured and the taller and denser the forest, the more important will this error become. At the top of Mount Banahao there is a forest the top story of which is composed almost entirely of *Podocarpus imbricatus*. On the ground under the forest there are very numerous seedlings of *Podocarpus*, but small trees are conspicuously absent. This would indicate that the seedlings start, but that conditions are unfavorable for them and that very few reach maturity. Evidently a measurement of the average rates of growth of these seedlings might bear very little, if any, relation to the rates of growth, as seedlings, of the trees now forming the main canopy. The determination, in a dense forest, of the seedlings or very small trees that will reach maturity is practically impossible. Therefore, in estimating the ages of trees from successive measurements of girth there must necessarily be considerable error due to the fact that there is so much uncertainty about the rates of growth of very small individuals. In the measurements on Mount Maquiling this error, as will be shown later, is not important except in the case of the smallest diameter classes.

GROWTH OF PARANG TREES

Nearly all tree species growing in the parang are small. A second-growth forest 10 meters in height would be considered exceptionally tall. The trees usually flower when small, many of the species producing seeds before reaching a meter in height. The second-growth trees are in many ways comparable with weeds in temperate countries. Their success is apparently due to the fact that they can quickly invade open ground or areas covered with low vegetation. As most of the species are in-

tolerant of shade, they of course disappear with the advent of species belonging to a more stable forest. Measurements are not necessary to prove that the small size of these trees is not connected with a slow rate of growth, as casual observation shows that they may cover an area in a few years, and that in the same length of time individuals may reach considerable dimensions. As a second-growth forest grows older it naturally becomes denser, owing to the large size of individual trees and also to invasion by vines and other plants. As density increases the rates of growth of course become slow; and under a second-growth forest the rate may be extremely slow. However, even second-growth trees growing in an open situation do not attain large dimensions, but mature and disappear at an early age.

Measurements of rates of growth of the parang species were begun January 21, 1913, and ended January 21, 1915. The trees were all in the neighborhood of the forest station, which was situated at the top of a broad ridge at the base of Mount Maquiling at an altitude of about 80 meters. The trees were in three different localities. A few were in the large lawn surrounding the station, and these are classified in the following tables as growing in the open. Many were in a young second-growth forest on the gently sloping side of the ridge. As the trees in this forest became larger, the canopy naturally increased in density, and this was accompanied by a decrease in the rates of growth. The remainder of the trees were in a plot used as a nursery for tree seedlings. As the trees in this plot grew larger, some were removed, so that they might not cast too dense a shade on the seedlings. Throughout the experiment, therefore, these trees were under conditions similar to those of trees growing in a very open forest. A few of the trees in the nursery were in a portion that was irrigated during the dry season. While this might be considered a decidedly artificial environment, it is similar to that of trees growing near a stream.

Owing to the diversity of conditions to which the trees measured were subjected, the measurements may be considered as giving a fair idea of the average rates of growth of trees under various conditions in this locality. Most of the trees less than 5 centimeters in diameter were in the forest. They were, therefore, subjected to shading by larger individuals and were probably growing at a slower rate than were those now composing the major portion of the canopy when the latter were in the 0- to 5-centimeter class. On the other hand, the rates of growth

calculated for the 0- to 5-centimeter class were all for trees approaching the upper limit of this class, and in some cases at least this may have had a tendency to make the rates of growth calculated for this class appear too high. In the measurement of the 0- to 5-centimeter class there were, therefore, two sources of error which probably counterbalanced each other to some extent. From observation of the rates of growth of young trees and from an examination of the rates shown in the tables, it seems hardly probable that these two sources have produced any very serious error in the general results obtained.

In the tables dealing with rates of growth of the parang species the individuals have been classified according to location; that is, as to whether they were in the open, in the forest, or in the nursery. They have, moreover, been grouped according to their diameter classes. The diameters of the trees at the time of the first measurement are also recorded, while the measurements for the two years are given separately. In a number of cases a tree in one diameter class grew sufficiently during the first year to place it in a larger diameter class the second year. In such cases the measurement for the second year appears in both classes. In the smaller class the measurement is given in italics and is not included in the calculation of the average rates of growth for that class. In the larger class the diameter recorded is that measured at the beginning of the second year. Thus, a tree measuring at the beginning of the period 4.58 centimeters in diameter and growing 1.90 centimeters during the first year has passed into the 5- to 10-centimeter class, and in this class its diameter is given as 6.48 centimeters. In a considerable number of cases measurements are given for the first and not for the second year. This is particularly true of trees growing in the nursery and is due to the fact that, as shading in the nursery became more intense, some trees were removed. In the other two situations there are also trees for which measurements were not obtained the second year. This was due to the removal of some trees during the construction of a road.

The tables also contain calculations of the number of years required by a tree to pass through the different diameter classes. At the end of each table is given a summary of the average rate of growth of all trees of a given diameter class and the number of years required by the average to pass through the different classes. For convenience the species forming the second-growth forest have been divided into two classes; namely, those that

reach a diameter of 20 centimeters or more, and those that do not attain a diameter of 20 centimeters.

DIAMETER GROWTH OF PARANG SPECIES THAT REACH A DIAMETER OF 20 CENTIMETERS OR MORE

Mallotus ricinoides.—This is a small tree that is frequently very prominent in the earlier stages of a second-growth forest. It is common and widely distributed in the Indo-Malayan region. Measurements of growth for this species are given in Table XXXII. Most of the individuals were in the young forest, while

TABLE XXXII.—*Annual diameter growth of Mallotus ricinoides (alim) at the base of Mount Maquiling; altitude, about 80 meters.*

[Diameters and growth are given in centimeters.]

Position of tree.	Diameter class in centimeters.											
	0 to 5.			5 to 10.			10 to 20.			20 to 30.		
	Diameter.	Growth.		Diameter.	Growth.		Diameter.	Growth.		Diameter.	Growth.	
		1913.	1914.		1913.	1914.		1913.	1914.		1913.	1914.
In the forest	4.83	1.55	*0.67*	9.28	0.84	*0.84*	16.92	4.35	*3.59*	21.27		3.59
Do	4.58	1.96	*1.91*	9.42	1.59	*1.11*	17.66	2.02	1.62			
Do	4.58	1.58	*1.78*	9.08	1.53	*1.21*	10.80	1.75	1.26			
Do				6.11	2.02	0.97	10.22	2.00	1.16			
Do				5.79	2.55	1.31	10.12		0.84			
Do				8.66	1.44	*0.94*	11.01		1.11			
Do				9.55	2.09	*1.16*	10.61		1.21			
Do				6.38		0.67	10.10		0.94			
Do				6.54		1.91	11.64		1.16			
Do				6.16		1.78						
Average		1.70			1.72	1.33		2.53	1.16			3.59
Years in class		2.9			2.9	3.8		4.0	8.6			2.8
In the nursery				6.73	3.08		10.22	1.02				
Do				7.63	3.16	*3.34*	11.99	3.13				
Do				7.10	3.35		10.79		3.34			
Average					3.20			2.07	3.34			
Years in class					1.6			4.8	3.0			

AVERAGE ANNUAL RATE OF GROWTH OF ALL TREES FOR 1913 AND 1914.

Diameter class.	Average rate of growth.	Years in class.
0 to 5 centimeters	1.70	2.9
5 to 10 centimeters	1.89	2.6
10 to 20 centimeters	1.79	5.6
20 to 30 centimeters	3.59	2.8

the remainder were in the nursery. It will be noticed that in only one case did a tree in the forest grow more rapidly during the second year than in the first, and that with two exceptions the trees showed a considerably slower rate of growth during the second year. This was very evidently due to greater crowding as the individuals became larger. In only one case were measurements obtained on a tree in the nursery for the two years and this one grew more in the second year than in the first. The average annual rates of growth of the 0- to 5-centimeter class was 1.7 centimeters; of the 5- to 10-class, 1.89; of the 10- to 20-class, 1.79; and of the 20- to 30-class, 3.59 centimeters. The last figure is based on the measurement of only one individual for the year 1914. This same individual was in the 10- to 20-centimeter class the previous year and showed the fastest growth of any tree in this class. This faster rate was probably due, at least in part, to its large size, which prevented it from receiving as much shade as did the smaller individuals.

With the exception of this largest class all of the diameter classes showed approximately the same rate of diameter growth. According to the estimated number of years it takes a tree to pass through the different diameter classes, a tree 30 centimeters in diameter would be 13.9 years of age.

In order to compare the rates of growth of the second-growth species at the base of Mount Maquiling with those of trees growing in the United States, the approximate time required to produce different wood crops has been taken from the Woodsman's Handbook* and is presented in Table XLII. In the original publication, these figures are found in Table LXIII, which gives the number of years required by different species to reach diameters of 6, 8, 11, 14, and 18 inches. In our Table XLII the data for 18 inches are omitted. For convenience we may compare the length of time required by these species to reach a diameter of 11 inches, or 27.9 centimeters, with the time required for *Mallotus* to attain a diameter of 30 centimeters. The fastest growing of the species for which data are given for a diameter of 11 inches is red gum in South Carolina, which attained this diameter in thirty years, whereas *Mallotus ricinoides* reaches a diameter of 30 centimeters in approximately fourteen years. In other words, *Mallotus ricinoides* apparently grows about twice as fast as the most rapidly growing species

* Graves, H. S., and Ziegler, E. A., The Woodsman's Handbook, *Bull. U. S. Dept. Agr., Forest Service* (1910), No. 36.

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mentioned in Table XLII. The number of years required by the average of all the species in Table XLII to reach a diameter of 11 inches is sixty-seven years.

Columbia serratifolia.—This species is a small tree, reaching a height of 10 to 14 meters, and has a fairly dense crown for a second-growth tree. It is widely distributed in the Philippines and is prominent in the second-growth forest at the base of Mount Maquiling. All trees measured were in the young forest, and the results are recorded in Table XXXIII. The average

TABLE XXXIII.—*Annual diameter growth of Columbia serratifolia (anilao) in young forest at the base of Mount Maquiling; altitude, about 80 meters.*

[Diameters and growth are given in centimeters.]

Position of tree.	Diameter class in centimeters.											
	0 to 5.			5 to 10.			10 to 20.			20 to 35.		
	Diameter.	Growth.		Diameter.	Growth.		Diameter.	Growth.		Diameter.	Growth.	
		1913.	1914.		1913.	1914.		1913.	1914.		1913.	1914.
In young forest	4.60	2.09	*2.41*	6.67	2.34	3.18	11.14	2.73	1.91	20.26	4.31	
Do				7.82	2.58	*2.32*	11.57	1.81	1.46	32.41	2.18	1.91
Do				6.69		2.41	10.40		2.32			
Do				6.83	0.77	0.19						
Average		2.09			1.89	1.93		2.27	1.90		3.24	1.91
Years in class		2.4			2.6	2.6		4.4	5.3		4.6	7.9

AVERAGE ANNUAL GROWTH FOR 1913 AND 1914.

Diameter class.	Average rate of growth.	Years in class.
0 to 5 centimeters	2.09	2.4
5 to 10 centimeters	1.91	2.6
10 to 20 centimeters	2.05	4.9
20 to 35 centimeters	2.80	5.4

annual rate of growth of all trees in the 0- to 5-centimeter class is 2.09 centimeters; in the 5- to 10-class, 1.91 centimeters; in the 10- to 20-class, 2.05 centimeters; and in the 20- to 35-class, 2.80 centimeters. As in the case of *Mallotus ricinoides* there is comparatively little difference in the rates of growth of the diameter classes 0 to 5, 5 to 10, and 10 to 20 centimeters. The 20- to 35-centimeter class showed a somewhat more rapid rate, which is probably due, as in the case of *Mallotus ricinoides*, to the fact that the large trees are not subject to as much shading

as are the smaller ones. The rate of growth of *Columbia serratifolia* is approximately the same as that of *Mallotus ricinoides*, as according to the calculations it takes a tree 15.3 years to reach a diameter of 35 centimeters.

Bauhinia malabarica.—This is a small tree with a dense crown, and is frequently prominent in the first stage of invasion of grassland by a second-growth forest. Its ability to endure in such situations is due to its being more fire-resisting than are most second-growth species.

The results of the measurements of *Bauhinia* are recorded in Table XXXIV. All of the trees except one were growing in

TABLE XXXIV.—*Annual diameter growth of Bauhinia malabarica (alibangbang) at the base of Mount Maquiling; altitude, about 80 meters.*

[Diameters and growth are given in centimeters.]

Position of tree.	Diameter class in centimeters.								
	5 to 10.			10 to 20.			20 to 30.		
	Diameter.	Growth.		Diameter.	Growth.		Diameter.	Growth.	
		1913.	1914.		1913.	1914.		1913.	1914.
In the open	5.72	3.15	4.14	18.40	2.40	*2.23*	23.58	2.73	3.08
Do							23.87	2.72	3.27
Do							20.80		2.23
In the forest	8.53	0.98	0.72						
Average		2.06	2.43		2.40			2.72	2.86
Years in class		2.4	2.1		4.2			3.7	3.5

AVERAGE ANNUAL GROWTH FOR 1913 AND 1914.

Diameter class.	Average rate of growth.	Years in class.
5 to 10 centimeters	2.25	2.2
10 to 20 centimeters	2.40	4.2
20 to 30 centimeters	2.81	3.6

the open, and with one exception those in the open showed a faster diameter growth during the second than the first year, whereas the tree in the forest showed a slower rate. This again points to the conclusion that, where the growth of trees in the forest was slower during the second year, the lower rate was due to crowding.

The 5- to 10-centimeter class has an average annual rate of growth of 2.25 centimeters; the 10- to 20-class, 2.40 centimeters; and the 20- to 30-class, 2.81 centimeters. The time required for

Bauhinia to grow from 5 to 30 centimeters is, according to the calculations, ten years; which would seem to show that this tree grows about as rapidly as the two species previously considered. Observations of the growth of seedlings, however, indicate that very young plants of *Bauhinia malabarica* grow more slowly than do those of most second-growth species.

Trema orientalis.—This species is intolerant of shade; it has small leaves and a very open canopy. It is widely distributed in the Indo-Malayan region and in the Philippines is a very common second-growth tree. It is particularly prominent in invasions of bare ground, where it frequently forms pure stands of considerable extent.* The rapid invasion of areas by this species has been discussed in connection with the general description of the parang and the dipterocarp forest. *Trema* is a small tree, reaching a height of from 5 to 8 meters, and during its earlier stages is an extremely rapid grower. The measurements of this species are given in Table XXXV. It will be seen that the

TABLE XXXV.—*Annual diameter growth of Trema orientalis (anabion) at the base of Mount Maquiling; altitude, about 80 meters.*

[Diameters and growth are given in centimeters.]

Position of tree.	Diameter class in centimeters.					
	10 to 20.			20 to 30.		
	Diameter.	Growth.		Diameter.	Growth.	
		1913.	1914.		1913.	1914.
In the open	11.90	3.67	3.85	25.91	1.36	0.94
Do	10.78	6.17	5.81			
In the forest	10.72	3.73	0.94	25.31	3.11	1.45
Average		4.52	3.53		2.23	1.19
Years in class		2.2	2.8		4.5	8.4

AVERAGE ANNUAL RATE OF GROWTH OF ALL TREES FOR 1913 AND 1914.

Diameter class.	Average rate of growth.	Years in class.
10 to 20 centimeters	4.03	2.5
20 to 30 centimeters	1.71	5.8

average rate of growth of trees in the 10- to 20-centimeter class was 4.03 centimeters per year, and that the greatest growth made

* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

by an individual during a year was 6.17 centimeters. The oldest individuals measured were approaching the age of maturity and showed a slower rate of growth than did the larger individuals of the three species previously considered.

TABLE XXXVI.—*Annual diameter growth of Litsea glutinosa (puso puso) at the base of Mount Maquiling; altitude, about 80 meters.*

[Diameters and growth are given in centimeters.]

Position of tree.	Diameter class in centimeters.					
	0 to 5.			5 to 10.		
	Diameter.	Growth. 1913.	Growth. 1914.	Diameter.	Growth. 1913.	Growth. 1914.
In the forest	3.24	0.24	0.22	7.67	2.05	0.65
Do	3.11	0.51	0.85	6.08	1.43	0.92
Do	3.59	0.79	0.78	5.52	0.65	0.67
Do	4.76	1.09	0.76	5.22	1.82	1.65
Do				5.85		0.76
Average		0.66	0.45		1.49	0.93
Years in class		7.6	11.1		3.4	5.4
In nursery	4.88	2.12	2.51	5.30	2.45	2.03
Do				5.14	1.77	1.65
Do				7.35	2.67	
Do				6.32	2.84	
Do				9.27	3.40	
Do				7.20	1.87	
Do				7.79	2.71	
Do				6.28	2.23	
Do				7.69	1.86	
Do				8.61	2.35	
Do				7.15	2.24	
Do				6.04	2.13	
Do				5.31	1.29	
Do				6.83	1.70	
Do				7.00	2.51	
Do				7.00		2.51
Average		2.12			2.27	2.06
Years in class		2.4			2.2	2.4

AVERAGE ANNUAL RATE OF GROWTH OF ALL TREES FOR 1913 AND 1914.

Diameter class.	Average rate of growth.	Years in class.
0 to 5 centimeters	0.76	6.6
5 to 10 centimeters	1.88	2.7

Litsea glutinosa.—This species reaches a height of 10 meters or less and has a moderately dense crown. It is widely distributed in the Philippines at low altitudes and in the Indo-Malayan region in general. In the Philippines it is rather common in second-growth forests.

The trees measured were in the forest and in the nursery. The results are presented in Table XXXVI. There were four individuals of the 0- to 5-centimeter class in the forest and one in the nursery. All of those in the forest had a comparatively slow rate of growth, the fastest being 1.09 centimeters and the average 0.55, while the individual in the nursery grew 2.12 centimeters. The slow rate of growth made by those in the forest is probably connected with the fact that they were small individuals and were shaded. The trees in the 5- to 10-centimeter class showed an annual rate of growth of 1.88 centimeters, which is approximately equal to that of the species previously considered.

Most of the individuals in the forest, as in the case of the other species, showed a slower rate of growth in the second than in the first year.

Macaranga spp.—These trees belong to two species, *M. bicolor* and *M. tanarius*. The two species are so very similar in general appearance that it is often impossible to distinguish them from sterile specimens. They have large leaves and spreading crowns which cast a fairly dense shade. Both species may be prominent in the invasions of cleared land by second-growth forest, and they also occur in considerable numbers in the early stages of the invasion of grassland by second-growth forests. The trees reach a height of 4 to 8 meters. *Macaranga tanarius* is widespread in the Malayan Peninsula and Archipelago and is common and widely distributed in the Philippines. *Macaranga bicolor* is endemic in the Philippines and is widely distributed in the northern part of the Islands.

The record of growth of these species is given in Table XXXVII. *Macaranga*, in the 5- to 10-centimeter class, showed a faster annual rate of growth, 2.83 centimeters, than any tree previously considered. Between 10 and 20 centimeters it showed about an average rate, 2.45 centimeters. The measurements of the 20- to 35-centimeter class were based on only two individuals, but these showed a lower average, 2.04 centimeters, than any of the other species except *Trema orientalis*. This is due, as in the case of *Trema*, to the fact that the older trees had passed their age of most rapid growth.

TABLE XXXVII.—*Annual diameter growth of Macaranga spp. (binuñga) at the base of Mount Maquiling; altitude, about 80 meters.*

[Diameters and growth are given in centimeters.]

Position of tree.	Diameter class in centimeters.								
	5 to 10.			10 to 20.			20 to 35.		
	Diameter.	Growth.		Diameter.	Growth.		Diameter.	Growth.	
		1913.	1914.		1913.	1914.		1913.	1914.
In young forest				14.77	3.04				
Do	8.90	4.25	*2.54*	16.67	2.45		32.63	2.66	2.27
Do	9.46	4.96		15.82	3.86		20.74	1.55	1.68
Do	9.27	2.20	*1.08*	11.67	3.35				
Do	5.52	2.48	2.73	10.98	2.55	2.31			
Do	8.33	2.34	*1.78*	13.15		2.54			
Do	5.40	1.87	1.72	11.47		1.08			
Do	8.25	3.52	*3.02*	10.67		1.78			
Do	7.62	3.30	*1.81*	11.77		3.02			
Do	9.29	1.32	*1.62*	10.92		1.81			
Do	8.06	2.50	*2.46*	10.61		1.62			
Do	5.33	2.41	2.58	10.56		2.46			
Do	6.11	2.30	1.97						
Do	5.69	2.35	2.16						
Average		2.75	2.23		3.05	2.08		2.10	1.97
Years in class		1.8	2.2		3.3	4.8		7.1	7.6
In nursery	5.08	3.01							
Do	5.92	2.62							
Do	5.19	3.52							
Do	9.86	4.43							
Do	9.05	3.55							
Do	7.10	3.08							
Do	7.94	3.56							
Average		3.40							
Years in class		1.5							

AVERAGE ANNUAL RATE OF GROWTH OF ALL TREES FOR 1913 AND 1914.

Diameter class.	Average rate of growth.	Years in class.
5 to 10 centimeters	2.83	1.8
10 to 20 centimeters	2.45	4.1
20 to 35 centimeters	2.04	7.4

The time required for *Macaranga* to grow from 5 to 35 centimeters in diameter is approximately the same as that required by the other species to make a growth of 30 centimeters. The more rapid growth of the trees in the forest during the first than the second year is again apparent.

Artocarpus cumingiana.—This is a medium-sized species and attains larger dimensions than any tree previously considered. It has large leaves, which are from 18 to 35 centimeters in length. It is found scattered along the edges of dipterocarp forests and on the moister slopes of drier types, and is not so characteristically a second-growth species as are the trees previously considered. *Artocarpus cumingiana* is endemic in the Philippines and is common and widely distributed at low and medium altitudes.

The rates of growth of *Artocarpus* are given in Table XXXVIII. The 0- to 5-centimeter class showed an annual rate of growth of 1 centimeter; the 5- to 10- class, an average rate of 1.53 centimeters; and the 10- to 20- class, 1.77 centimeters. *Artocarpus* thus appears to have a slower rate of growth than any of the species previously discussed. According to the calculations it requires 13.9 years to reach a diameter of 20 centimeters, which is exactly the length of time required by *Mallotus ricinoides* to reach a diameter of 30 centimeters.

TABLE XXXVIII.—*Annual diameter growth of Artocarpus cumingiana (anubing) at the base of Mount Maquiling; altitude, about 80 meters.*

[Diameters and growth are given in centimeters.]

Position of tree.	Diameter class in centimeters.								
	0 to 5.			5 to 10.			10 to 20.		
	Diameter.	Growth.		Diameter.	Growth.		Diameter.	Growth.	
		1913.	1914.		1913.	1914.		1913.	1914.
In the forest				6.73	1.53	1.59	10.70		1.60
Do				6.12	1.73	1.60			
Do				9.00	1.70	1.60			
Do				6.41	1.33	1.24			
Do				5.73	1.37	1.64			
Average					1.53	1.52			1.60
Years in class					3.1	3.3			6.3
In nursery	4.32	1.00		5.34	2.67		11.48	1.95	

AVERAGE ANNUAL RATE OF GROWTH OF ALL TREES FOR 1913 AND 1914.

Diameter class.	Average rate of growth.	Years in class.
0 to 5 centimeters	1.00	5.0
5 to 10 centimeters	1.53	3.3
10 to 20 centimeters	1.77	5.6

Miscellaneous species.—Besides the above-mentioned trees, a few individuals of a number of other species were also measured. The results are given in Table XXXIX. The average rates of growth of these miscellaneous species are very similar to those of the species already considered.

TABLE XXXIX.—*Annual diameter growth of miscellaneous trees that reach a diameter of 20 centimeters or more at the base of Mount Maquiling; altitude, about 80 meters.*

[Diameters and growth are given in centimeters.]

Species.	Position of tree.	Diameter class in centimeters.					
		5 to 10.			10 to 20.		
		Diameter.	Growth.		Diameter.	Growth.	
			1913.	1914.		1913.	1914.
Cordia myxa (anonang)	In the forest				16.64	1.85	1.24
Do	do				15.32	2.23	0.64
Do	do				15.65	2.15	0.62
Do	do				14.18	2.48	0.79
Do	In the open				13.44	3.89	
Alstonia scholaris (dita)	In nursery	7.52	3.30	3.47			
Sapindus saponaria	In the forest	7.69	1.28	0.79			
Do	In nursery	7.74	2.85				
Do	do	5.39	1.80				
Antidesma ghaesembilla	In the forest				19.40	1.97	
Mallotus philippensis (banato)	do				11.20	1.74	1.12
Canarium villosum	do	6.03	1.80				
Do	do	5.62	2.23	2.07			
Do	do	6.22	1.61	1.95			
Glochidion philippicum	do	7.40	2.31	1.62			
Polyscias nodosa	do	8.00	1.87	1.54			
Litsea perrottetii (marang)	In the open				15.19	2.15	
Premna odorata	In nursery				7.03	2.12	
Ficus nota (tibig)	In the forest				6.96	1.58	0.92
Do	do				9.01	1.55	0.92
Do	do				7.00	4.46	
Do	do				7.14	4.82	
Average			2.12	1.91		2.20	0.89
Years in class			2.4	2.6		4.5	11.2

DISCUSSION OF GROWTH OF SECOND-GROWTH SPECIES THAT REACH A DIAMETER OF 20 CENTIMETERS OR MORE

In Table XL are given the average rates of growth of individuals belonging to species that reach a diameter of 20 centimeters or more. The average annual rate of growth for the 0- to 5-centimeter class was 1.39 centimeters; for the 5- to 10- class, 2.08 centimeters; for the 10- to 20- class, 2.19 centimeters; and for the 20- to 30- or the 35- class, 2.59 centimeters. Ac-

cording to the calculations of the number of years required for the average second-growth tree to pass through the different diameter classes, such a tree would reach a diameter of 30 centimeters in 14.5 years. An average second-growth tree of 30 or 35 centimeters in diameter has about attained a maximum size, and it is either in a stage where it is losing its vitality or is nearing that stage.

TABLE XL.—*Average annual diameter growth of species that reach a diameter of more than 20 centimeters at the base of Mount Maquiling; altitude, about 80 meters.*

[Growth is given in centimeters.]

Species.	Diameter class in centimeters.			
	0 to 5.	5 to 10.	10 to 20.	20 to 30 or 35.
Trema orientalis (anabion)			4.03	1.71
Columbia serratifolia (anilao)	2.09	1.91	2.05	2.80
Bauhinia malabarica (alibangbang)		2.25	2.40	2.81
Litsea glutinosa (puso puso)	0.76	1.86		
Macaranga spp. (binuñga)		2.83	2.45	2.04
Artocarpus cumingiana (anubing)	1.00	1.53	1.77	
Mallotus ricinoides (alim)	1.70	1.89	1.79	3.59
Cordia myxa (anonang)			1.76	
Alstonia scholaris (dita)		3.38		
Sapindus saponaria		1.68		
Antidesma ghaesembilla			1.97	
Mallotus philippensis (banato)			1.43	
Canarium villosum		1.93		
Glochidion philippicum		1.96		
Polyscias nodosa		1.70		
Litsea perrottetii (marang)			2.15	
Premna odorata			2.12	
Ficus nota (tibig)			2.37	
Average	1.39	2.08	2.19	2.59
Years in class	3.6	2.4	4.6	[a] 3.9

[a] Calculated for 10 centimeters.

The fastest rates of diameter growth shown by the various species in the different diameter classes are given in Table XLI. In this table the rates of all the species are recorded except those of the miscellaneous ones that were represented by only one individual. The average of these fastest rates of growth for the 0- to 5-centimeter class is 1.79 centimeters; for the 5- to 10- class, 3.25 centimeters; for the 10- to 20- class, 3.73 centimeters; and for the 20- to 30- or the 35- class, 3.09 centimeters. According to these figures the average of these fastest-growing individuals should reach a diameter of 30 centimeters in ten years; a similar rate is shown by *Columbia serratifolia*,

while *Mallotus ricinoides* shows a rate of 30 centimeters in nine years. From these calculations it seems probable that an average second-growth tree under favorable conditions may reach full size in nine or ten years.

TABLE XLI.—*Fastest rates of diameter growth shown by species that reach a diameter of 20 centimeters or more at the base of Mount Maquiling; altitude, about 80 meters.*[a]

[Rates of growth are given in centimeters.]

Species.	Diameter class in centimeters.			
	0 to 5.	5 to 10.	10 to 20.	20 to 30 or 35.
Trema orientalis (anabion)			6.17	3.11
Columbia serratifolia (anilao)	2.09	3.18	2.73	4.31
Bauhinia malabarica (alibangbang)		4.14	2.40	3.27
Litsea glutinosa (puso puso)	2.12	3.40		
Macaranga spp. (binunga)		4.96	3.86	2.66
Mallotus ricinoides (alim)	1.96	3.35	4.35	3.59
Artocarpus cumingiana (anubing)	1.00	1.70	1.60	1.60
Cordia myxa (anonang)			3.89	
Alstonia scholaris (dita)		3.47		
Sapindus saponaria		2.85		
Canarium villosum		2.23		
Ficus nota (tibig)			4.82	
Average	1.79	3.25	3.73	3.09
Years in class	2.8	1.5	2.7	[b]3.2

[a] Species represented by one individual are omitted, except in the case of *Alstonia scholaris*.
[b] Calculated for 10 centimeters.

TABLE XLII.—*Approximate time required to produce different wood crops in the United States. Data taken from The Woodsman's Handbook, table 63.*

Species.	Locality.	Diameter.			
		6 inches, 15.2 cm.	8 inches, 20.3 cm.	11 inches, 27.9 cm.	14 inches, 35.6 cm.
NORTHERN FOREST.		*Years.*	*Years.*	*Years.*	*Years.*
Aspen	Maine	30	40	60	
Beech[a]	Michigan		80	100	
Birch, paper	Maine		50		
Birch, yellow	New York		85		
Hemlock[a]	Michigan		100	130	
Maple, sugar[a]	do		90		
Pine, jack	Minnesota	30	45		
Pine, red	Wisconsin	32	40	55	75
Pine, white	New York	32	40	55	
Spruce, red	do		85		
Tamarack	Minnesota	65		150	

[a] Species tolerant of shade which should show better results in second growth.

TABLE XLII.—*Approximate time required to produce different wood crops in the United States. Data taken from The Woodsman's Handbook, table 63*—Continued.

Species.	Locality.	Diameter.			
		6 inches, 15.2 cm.	8 inches, 20.3 cm.	11 inches, 27.9 cm.	14 inches, 35.6 cm.
CENTRAL HARDWOOD FOREST.		*Years.*	*Years.*	*Years.*	*Years.*
Chestnut [b]	Maryland	20	25	40	55
Hickory (mockernut) [b]	Mississippi	50	65		
Oak, black	Kentucky	25	35	50	
Oak, red	do	25	30	45	
Oak, white	do	35	45	80	
Poplar, yellow	Tennessee [c]		45		
Poplar, yellow [b]	Virginia [d]	20	25		
FARM-TIMBER PLANTATIONS.					
Catalpa [b]	Illinois	20			
Larch, European [b]	do	23			
Maple, silver [b]	do		25		
Walnut, black [b]	do	25	35		
Cottonwood [b]	Nebraska		18		
SOUTHERN FOREST.					
Ash, white	Arkansas		30	45	
Cedar, eastern red	Alabama	35	45	65	
Cottonwood	Mississippi		15		
Cypress	Maryland	40		65	75
Gum, red	South Carolina			30	
Pine, loblolly	do	20	25	40	55
Pine, longleaf	do			75	100
Pine, scrub	Maryland	30	40	70	
Pine, shortleaf	Arkansas		55	75	100
ROCKY MOUNTAIN FOREST.					
Fir, Douglas	Southern Idaho	50	60	75	
Pine, lodgepole	Montana	45		100	
Pine, western yellow	Arizona	40	50	75	
PACIFIC COAST FOREST.					
Fir, Douglas	Washington	25	35	45	50
Fir, white	California		75		
Hemlock, western	Washington		50	70	
Pine, sugar	California	40	50	65	
Pine, western yellow	do	25	35	45	55
Redwood	do	20	25	35	50
Average		32	47	67	68

[b] Species growing under favorable conditions when measured.
[c] Virgin forest.
[d] Second growth.

TABLE XLIII.—*Comparison between the number of years required by second-growth and United States species to reach certain diameters.*

Species.	Locality.	Diameter. 6 inches, 15.2 cm.	8 inches, 20.3 cm.	11 inches, 27.9 cm.	14 inches, 35.6 cm.
		Years.	*Years.*	*Years.*	*Years.*
Average of species in Table XLII	United States	32	47	67	68
Average of species in Table XL	Base of Mount Maquiling	8	11	14	17
Columbia serratifolia	do	7	10		15
Mallotus ricinoides	do	8	11	13	
Artocarpus cumingiana	do	11	14		
Macaranga spp	do	6	8		15
Gum, red	South Carolina			30	
Redwood	California	20	25	35	50
Pine, loblolly	South Carolina	20	25	40	55
Cottonwood	Nebraska		18		
Do	Mississippi		15		

It will be seen that a second-growth forest reaches its maximum size in a comparatively few years. In Table XLIII are brought together the average rates of growth of all the American species in Table XLII; the average rates of growth of such second-growth species at the base of Mount Maquiling as attain a diameter of 20 centimeters or more; the rates of *Columbia serratifolia, Macaranga* spp., *Mallotus ricinoides,* and *Artocarpus cumingiana* at the base of Mount Maquiling; and of the fastest-growing American species listed in Table XLII, namely red gum and loblolly pine in South Carolina, redwood in California, and cottonwood in Nebraska and Mississippi. For convenience in making comparisons, the number of years required for the species at the base of Mount Maquiling to reach the diameters mentioned in Table XLII have been calculated. A comparison of the rates of growth of these various species is shown graphically in fig. 1. An examination of Table XLIII shows that the average rate of growth of the second-growth species at the base of Mount Maquiling was approximately four times the average rate of the American species given in Table XLII. The only American species that approaches the average second-growth species in rapidity of growth is cottonwood in Mississippi, which attains a diameter of 8 inches in 15 years, while the average of the second-growth species reaches the same diameter in 11 years. It will be noted, however, that *Macaranga* showed a rate of growth about twice as rapid as that of cottonwood in Mississippi. The second-growth species, with the exception of *Artocarpus cumin-*

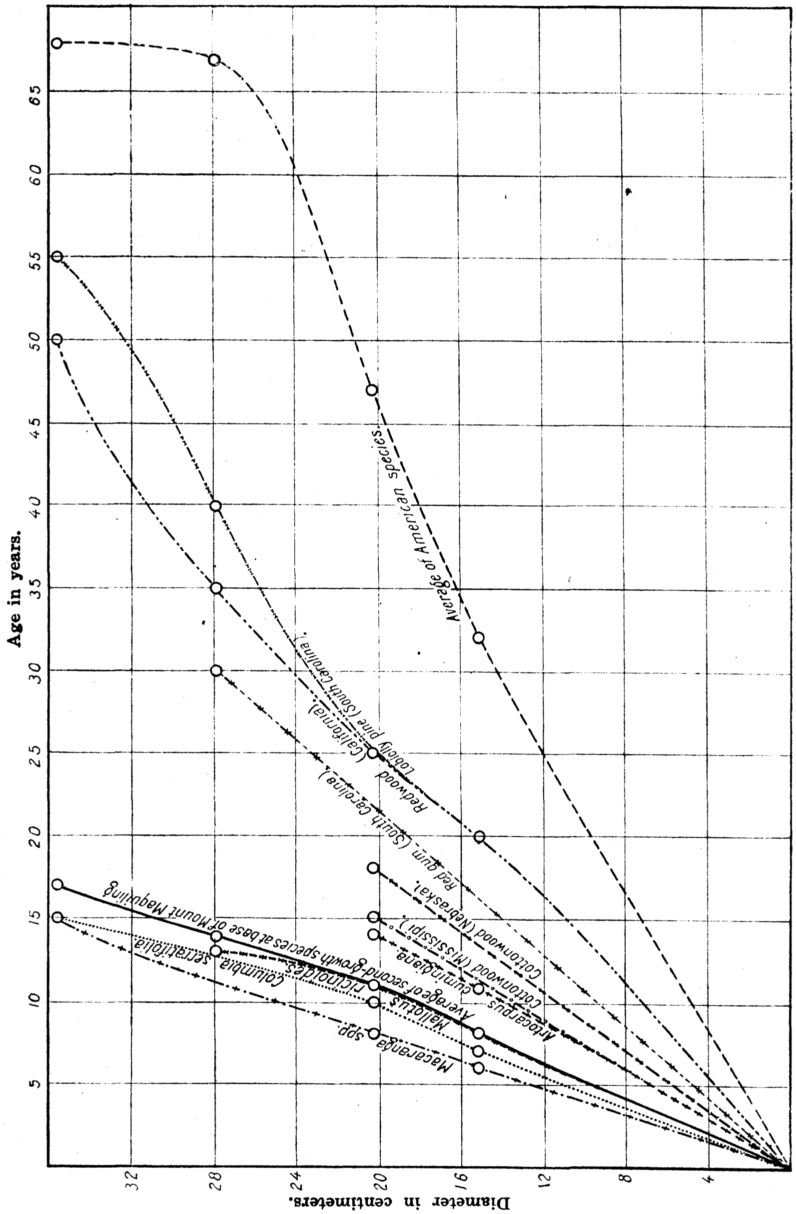

FIG. 1. Rates of growth of second-growth trees at the base of Mount Maquiling compared with the rates of growth of trees in the United States.

giana, grow more than twice as rapidly as red gum and loblolly pine in Carolina, or redwood in California. The average calculated age of a second-growth tree 6 inches, or 15 centimeters, in diameter is 8 years, while redwood and loblolly pine of the same size are 20 years old. In order to attain a diameter of 14 inches, or 35.6 centimeters, redwood would require 50 years and loblolly

pine 55 years; while the average second-growth tree requires only 17 years; *Columbia serratifolia,* 15 years; and *Macaranga* spp., 15 years.

The rapid growth made by the second-growth species at the base of Mount Maquiling is not characteristic of all tropical trees. Brown and Matthews* have shown that trees growing in the virgin forest may have a very slow rate of growth. In the early stages this may be much slower than that of temperate-zone

TABLE XLIV.—*Annual diameter growth of Pterocarpus indicus and Enterolobium saman in the open at the base of Mount Maquiling; altitude, about 80 meters.*

[Diameters and growth are given in centimeters.]

Species.	Diameter class in centimeters.								
	5 to 10.			10 to 20.			20 to 30.		
	Diameter.	Growth.		Diameter.	Growth.		Diameter.	Growth.	
		1913.	1914.		1913.	1914.		1913.	1914.
Enterolobium saman (rain tree)	6.18	5.85	*7.41*	10.16	10.78	*10.50*	20.94		10.50
Do				12.03		7.41			
Pterocarpus indicus (narra)	6.77	5.25	*4.89*	12.02		4.89			

ANNUAL RATE OF GROWTH FOR 1913 AND 1914.

Diameter class.	*Enterolobium saman.*		*Pterocarpus indicus.*	
	Growth.	Years in class.	Growth.	Years in class.
5 to 10 centimeters	5.85	0.9	5.25	1.0
10 to 20 centimeters	9.09	1.1	4.89	2.0
20 to 30 centimeters	10.50	1.0		

trees. The more rapid growth of the second-growth trees is due in part, of course, to the fact that they are not shaded as are the smaller trees in the virgin forest. The very rapid growth is moreover connected with the individual peculiarities of the species, for many trees of the tropics—perhaps most of them—do not show such extremely rapid rates of growth. Most fruit trees and many of the better shade trees grow comparatively slowly, and it will be shown later that forest trees in the open may make

* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

a much slower growth than the second-growth trees. The second-growth trees mentioned do not, however, show an extreme rate for tropical trees. In Table XLIV are given the rates of growth of two individuals of *Enterolobium saman* and one of *Pterocarpus indicus*.

Enterolobium saman is a native of the West Indies and is widely used in the tropics as a shade tree. It is a medium-sized tree, reaching a height of 20 to 25 meters, and has wide-spreading branches. The faster-growing of the two individuals of *Enterolobium* grew 10.78 centimeters in diameter during the first year and 10.50 during the second. This rate is much more rapid than that of any individual of the second-growth trees measured. The other *Enterolobium* grew 5.85 centimeters the first year and 7.41 the second. This also is a faster rate than that shown by any second-growth individual. According to the calculations made for these two individuals, it would take only three years for *Enterolobium* to grow 25 centimeters in diameter. While this rate appears rapid, a much higher rate would probably be shown by measuring a greater number of individuals of *Enterolobium;* but these two were the only ones available for measurement at the forest station at the base of Mount Maquiling.

Pterocarpus indicus (narra) is a medium-sized forest tree, reaching a height of 20 to 30 meters and an average diameter of 70 to 80 centimeters. An exceptional tree may reach a diameter of 150 to 200 centimeters. Narra does best in fairly open situations and is nearly deciduous for a short time during the dry season. The wood produced by this species is very valuable for cabinet work, furniture, etc. A considerable number of individuals of narra were grown in the plantation of the Bureau of Forestry at the forest station. One individual growing in the open in a favorable situation made an exceptionally rapid growth, and the measurements of this individual are the ones that are given in Table XLIV. During the first year it made a growth of 5.25 centimeters, and during the second, 4.89 centimeters. This rate of growth would be very rapid for a second-growth species, but it must be remembered that this was an exceptional tree.

ANNUAL DIAMETER GROWTH OF SECOND-GROWTH SPECIES THAT DO NOT REACH A DIAMETER OF 20 CENTIMETERS

Ficus hauili.—This species is a small tree, reaching a height of 3 to 8 meters. It is endemic in the Philippines and is distributed throughout the Islands at low altitudes. *Ficus hauili*

is prominent in the second growth at the base of Mount Maquiling.

TABLE XLV.—*Annual diameter growth of Ficus hauili (hauili) at the base of Mount Maquiling; altitude, about 80 meters.*

[Diameters and growth are given in centimeters.]

Position of tree.	Diameter class in centimeters.								
	0 to 5.			5 to 10.			10 to 15.		
	Diameter.	Growth.		Diameter.	Growth.		Diameter.	Growth.	
		1913.	1914.		1913.	1914.		1913.	1914.
In the forest	4.71	2.05	*0.98*	7.72	2.82		14.09	0.93	
Do	4.77	1.09	*0.64*	7.11	2.01		13.20	1.56	
Do	3.32	0.58		5.74	1.68	0.94	12.82	1.43	
Do	3.90	3.32		9.49	2.20	*1.38*	11.69		1.38
Do				5.00	1.26	0.46			
Do				6.38	2.45	1.22			
Do				5.23	1.64	0.79			
Do				6.76		0.98			
Do				5.86		0.64			
Average		1.76			2.00	0.84		1.31	1.38
Years in class		2.8			2.5	6.0		3.8	3.6
In nursery				8.60	1.59	*2.07*	11.38	2.24	4.75
Do				5.02	2.57	3.40	10.64	3.85	2.32
Do				9.19	2.38		10.19		2.07
Do				6.68	2.83				
Do				5.62	2.23				
Do				9.01	4.14				
Do				7.15	3.84				
Do				5.24	2.15	2.00			
Average					2.72	2.70		3.04	3.05
Years in class					1.9	1.85		1.6	1.6

AVERAGE ANNUAL RATE OF GROWTH OF ALL TREES FOR 1913 AND 1914.

Diameter class.	Average rate of growth.	Years in class.
0 to 5 centimeters	1.76	2.8
5 to 10 centimeters	2.01	2.5
10 to 15 centimeters	2.28	2.2

The rates of growth of this species are recorded in Table XLV. They are similar to those for species attaining a diameter of 20 or more centimeters. The average rate of growth of the 0- to 5-centimeter class is 1.76 centimeters; of the 5- to 10-class, 2.01 centimeters; and of the 10- to 15-class, 2.28 centimeters. According to these figures it would take a tree 7.5 years to reach

a diameter of 15 centimeters. *Ficus hauili* made the second most rapid growth of any species classified as not reaching a diameter of 20 centimeters.

The individuals of *Ficus hauili* were in the forest and in the nursery. It will be noted that no individual in the forest made so rapid a growth during the second as in the first year, while three of the five in the nursery, for which two years' measurements were obtained, grew more rapidly the second year than the first. The species in question, like those previously considered, had a slower rate of growth when the forest became more crowded.

TABLE XLVI.—*Annual diameter growth of Ficus ulmifolia (isis) at the base of Mount Maquiling; altitude, about 80 meters.*

[Diameters and growth are given in centimeters.]

Position of tree.	Diameter class in centimeters.					
	0 to 5.			5 to 10.		
	Diameter.	Growth. 1913.	Growth. 1914.	Diameter.	Growth. 1913.	Growth. 1914.
In the forest	3.77	0.21	0.23	5.81	2.05	0.95
Do	3.43	0.77	0.22	5.70	0.37	
Average		0.49	0.22		1.26	0.95
Years in class		10.2	22.7		4.0	5.3
In the open				7.79	0.85	0.73
In nursery				6.90	1.30	
Do				5.73	1.31	
Do				5.00	2.21	
Do				6.40	0.76	
Do				4.85	1.27	
Do				6.12	2.37	
Do				6.20	2.88	
Do				6.40	3.30	
Do				6.92	4.68	
Do				6.91	3.37	
Do				6.71	2.77	
Do				5.31	1.03	
Average					2.27	
Years in class					2.2	

AVERAGE ANNUAL RATE OF GROWTH OF ALL TREES FOR 1913 AND 1914.

Diameter class.	Average rate of growth.	Years in class.
0 to 5 centimeters	0.36	13.9
5 to 10 centimeters	1.89	2.6

Ficus ulmifolia.—This species is usually a very small tree, reaching a height of from 3 to 5 meters. It is endemic in the Philippines and is rather common in the second-growth forests throughout the Archipelago.

TABLE XLVII.—*Annual diameter growth of Premna cumingiana (maguili) at the base of Mount Maquiling; altitude, about 80 meters.*

[Diameters and growth are given in centimeters.]

Position of tree.	Diameter class in centimeters.					
	0 to 5.			5 to 10.		
	Diameter.	Growth.		Diameter.	Growth.	
		1913.	1914.		1913.	1914.
In the forest	4.02	0.27	0.63	7.50	1.55	0.99
Do	4.40	0.25	0.27	7.06	0.82	0.52
Do	4.37	1.12	*0.03*	6.20	0.29	0.48
Do	4.30	0.17	0.08	5.49	--------	0.03
Do	4.39	0.32	0.13	--------	--------	--------
Average	--------	0.43	0.28	--------	0.89	0.50
Years in class	--------	11.6	17.8	--------	5.6	10.0
In nursery	4.98	1.23	--------	6.36	0.22	--------
Do	4.23	1.00	--------	8.26	1.59	--------
Do	--------		--------	6.89	1.47	--------
Do	--------		--------	5.09	1.50	--------
Do	--------		--------	7.50	1.55	--------
Average	--------	1.11	--------	--------	1.27	--------
Years in class	--------	4.5	--------	--------	3.9	--------

AVERAGE ANNUAL RATE OF GROWTH OF ALL TREES FOR 1913 AND 1914.

Diameter class.	Average rate of growth.	Years in class.
0 to 5 centimeters	0.50	10.0
5 to 10 centimeters	.92	5.4

The rates of growth of this species are recorded in Table XLVI. All individuals measured were less than 10 centimeters in diameter at the time of the first measurement. The small individuals of *Ficus ulmifolia* showed a very slow rate of growth, the 0- to 5-centimeter class averaging only 0.36 centimeter. The larger individuals, however, made a more rapid growth, the 5- to 10-class averaging 1.89 centimeters. As in the case of the

other species, the trees in the forest made a slower growth during the second year than the first. The trees in the nursery, where they were not crowded, showed a considerably faster rate than did those in the forest. According to the calculations of rates of growth the average individual of *Ficus ulmifolia* requires 16.5 years to reach a diameter of 15 centimeters.

Premna cumingiana.—This species is a very small tree. It is endemic in the Philippines and is common and widely distributed in second-growth forests at low altitudes.

The results of the measurements of this species are given in Table XLVII. They show a slower rate of growth than that of any of the species so far considered, the average rate of the 0- to 5-centimeter class being 0.5 centimeter and of the 5- to 10-class, 0.92 centimeter. These figures would seem to show that it would take an individual 15.4 years to reach a diameter of 10 centimeters.

Miscellaneous species.—In addition to the species discussed measurements were made of a few individuals of a number of different species that do not reach a diameter of 20 centimeters. The results are given in Table XLVIII. One of these, *Melochia umbellata,* is of particular interest. This is the most numerous species in the second-growth forest at the base of Mount Maquiling and shows a rapid rate of growth. When young it has a smooth bark; but, as it reaches full size, the bark becomes very rough and irregular, so that it is not practicable to determine the rates of growth of old individuals by the methods adopted. Measurements were started on a considerable number of individuals, but in only five cases did the bark remain smooth throughout the first year. The results of the measurements of these five individuals are given in Table XLVIII. The fastest growth made was 5.02 centimeters, while the average rate was 3.27. This is the fastest average rate recorded for any of the trees that do not reach a diameter of 20 centimeters and, with two exceptions, was faster than that of any single diameter class of any species that attains a greater diameter. When *Melochia* has grown to approximately full size, the bark rapidly becomes rough, and the trees die in a comparatively short time. From the average rate of growth recorded in Table XLVIII it would seem that this species may reach maturity and die in three or four years.

The other miscellaneous species showed a slower rate of growth than *Melochia umbellata.*

TABLE XLVIII.—*Annual diameter growth of miscellaneous trees which do not reach a diameter of 20 centimeters at the base of Mount Maquiling; altitude, about 80 meters.*

[Diameters and growth are given in centimeters.]

Species.	Position of tree.	Diameter class in centimeters.					
		0 to 5.			5 to 10.		
		Diameter.	Growth.		Diameter.	Growth.	
			1913.	1914.		1913.	1914.
Leucaena glauca (ipil ipil)	In the forest				9.19	1.37	1.21
Dysoxylum decandrum	In the open				8.51	0.71	0.35
Pipturus arborescens (dalunot)	do				9.06	1.58	0.83
Do	do				5.78	2.04	
Do	In nursery				6.30	0.78	
Melochia umbellata (labayo)	In the open				7.74	4.34	
Do	In nursery				8.93	5.02	
Do	do				8.13	3.53	
Do	do				5.74	1.20	
Do	do				7.98	2.24	
Voacanga globosa (bayag-usa)	In the forest	3.91	0.94	0.38	5.28	1.03	0.68
Do	In nursery				6.79	2.67	
Do	do				5.11	2.01	
Mussaenda philippica (cahoy dalaga).	In the forest	4.51	0.87	0.67			
Ficus sp	do	3.49	0.35	0.22			
Leea manillensis	do	4.64	1.09	0.32	6.48	0.38	0.63
Do	do	4.86	0.21		5.73		0.32
Do	do	4.32	0.63	0.38			
Psidium guajava (guava)	do	3.56	0.16	0.29	8.00	1.70	1.05
Do	do				6.86	0.29	0.22
Do	do				5.56	0.53	0.24
Do	In nursery	4.99	1.71		7.89	1.39	
Mallotus moluccanus	In the forest				5.30	0.43	0.25
Do	do				7.69	0.25	0.67
Do	do				8.19	1.64	0.87
Do	do				5.45	0.37	0.37
Do	In nursery				8.69	2.55	
Average			0.75	0.39		1.65	0.59
Years in class			6.7	12.8		3.0	8.5

SUMMARY OF RATES OF GROWTH OF SMALL SECOND-GROWTH SPECIES

In Table XLIX are recorded the average rates of growth of the different diameter classes of all trees that do not reach a diameter of 20 centimeters. The rate of growth of the 0- to 5-class was 0.64 centimeter; of the 5- to 10-class, 1.40 centimeters; and of the 10- to 15-class, 1.60 centimeters. According to these figures it would take an average tree 11.4 years to reach a diameter of 10 centimeters and 14.5 years to attain a diameter of 15 centimeters. The average rates of growth are

much slower than those of the species that reach a diameter of more than 20 centimeters. According to the figures given in Table XL a diameter of 30 centimeters is attained in the same length of time that would be required by the average of the small trees to reach a diameter of 15 centimeters. It would thus appear that the average smaller species and the average larger species reach maturity in about the same length of time.

TABLE XLIX.—*Average annual diameter growth of species which do not reach a diameter of 20 centimeters at the base of Mount Maquiling; altitude, about 80 meters.*

[Growth is given in centimeters.]

Species.	Diameter class in centimeters.		
	0 to 5.	5 to 10.	10 to 15.
Ficus ulmifolia (isis)	0.36	1.89	
Ficus hauili (hauili)	1.76	2.01	2.28
Premna cumingiana (maguili)	0.50	0.92	
Leucaena glauca (ipil ipil)		1.29	
Dysoxylum decandrum		0.53	
Pipturus arborescens (dalunot)		1.81	
Melochia umbellata (labayo)		3.27	
Voacanga globosa (bayag-usa)	0.66	1.60	
Mussaenda philippica (cahoy dalaga)	0.77		
Ficus sp	0.28		
Leea manillensis	0.58	0.44	
Psidium guajava (guava)	0.22	0.77	0.92
Mallotus moluccanus (alim)		0.82	
Average	0.64	1.40	1.60
Years in class	7.8	3.6	3.1

GENERAL DISCUSSION

A consideration of the rates of growth of second-growth species shows very clearly that their small size is not connected with a slow rate of growth; it also emphasizes the fact that they are weed species that can quickly invade open ground, mature early, and produce seeds before a more stable forest has had time to develop. The rapid growth of the species does, however, show that conditions at the base of Mount Maquiling are very favorable for plant growth. In the same locality agricultural crops that can stand a short but not very severe dry season do well. It may, therefore, be concluded that environmental conditions at the base of Mount Maquiling are favorable for plant growth. As previously pointed out, the few scattered specimens of large trees remaining from the original forest indicate that this area was originally covered by a tall forest.

GROWTH IN DIPTEROCARP FOREST

Measurements of the rates of growth of trees in the dipterocarp forest of Mount Maquiling were begun by Mr. D. M. Matthews and the writer in January, 1913. The results of the first year's measurements on Mount Maquiling, together with those of more extensive measurements in other dipterocarp forests, have been published in considerable detail.* The measurements here presented are in continuation of those started by Brown and Matthews in 1913 and cover four years. The results are essentially similar to those published; and, as these rates of growth have previously been compared with those in other regions in the Philippines, as well as in America, no extensive comparison of the rates for trees in the dipterocarp forest on Mount Maquiling with those in other localities will be attempted.

The measurements in the dipterocarp forest of Mount Maquiling were taken at an elevation of approximately 300 meters, in an area in which there has been very little logging. This area was on the side of Molàuin River opposite station 2 and about the same distance from the river as was this station. The environmental conditions may, therefore, be considered as practically the same as those obtaining at station 2.

The three species concerned are *Parashorea malaanonan* (bagtican lauan) which, it will be remembered, is the dominant tree in the dipterocarp forest; *Diplodiscus paniculatus* (balobo), a second-story tree, which is the most numerous tree species in the forest; and *Dillenia philippinensis* (catmon), which is another common second-story tree.

The first measurements of *Parashorea* were taken on January 13, 1913; the second, January 13, 1914; the third, January, 1915; and the fourth, in January, 1917. The results are presented in Table L, in which are given the diameters at the time of the first measurement, the diameter growth for 1913 and 1914, and the average annual diameter growth for 1915 and 1916; also the average rates of growth for the four-year period and the average number of years that it would take, according to these figures, for a tree to pass through a given diameter class.

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* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

TABLE L.—*Annual diameter growth of Parashorea malaanonan (bagtican lauan) in virgin forest on Mount Maquiling; altitude, about 300 meters.*

[Diameters and growth are given in centimeters.]

No. of tree in class.	Diameter class in centimeters.							
	0 to 5.				5 to 10.			
	Diameter.	Annual growth. 1913.	1914.	1915 and 1916.	Diameter.	Annual growth. 1913.	1914.	1915 and 1916.
1	3.88	0.112	0.000		5.19	0.143	0.000	0.000
2	4.15	0.217	0.175	0.016	7.40	0.121	0.194	0.119
3	4.61	0.000	0.032	0.056	7.29	0.395	0.194	0.923
4	2.43	0.070	0.192		9.11	0.339	0.159	0.374
5					6.28	0.378	0.016	0.016
6					5.56	0.366	0.317	
7					7.18	0.280	0.079	
8					8.80	0.447	0.445	
9					5.39	0.280	0.588	
10					5.80	0.028	0.192	
Average		0.10	0.10	0.04		0.28	0.22	0.29
Years in class		50	50	125		18	23	17
Average annual growth for four years		0.07				0.27		
Average years in class		71				19		

No. of tree in class.	Diameter class in centimeters.							
	10 to 20.				20 to 30.			
	Diameter.	Annual growth. 1913.	1914.	1915 and 1916.	Diameter.	Annual growth. 1913.	1914.	1915 and 1916.
1	14.92	0.127	0.032	0.032	25.70	0.445	0.446	0.295
2	19.35	1.112	1.002	0.803	27.50	1.045	1.208	1.002
3	15.00	0.236	0.032	0.016	29.20	0.617	0.572	0.406
4	19.55	0.497	0.223	0.446	29.95	0.445	0.350	0.135
5	13.21	0.318	0.207	1.511	27.00	1.006	1.050	0.708
6	17.38	0.141	0.159	0.127	22.65	0.620	0.732	0.485
7	15.78	0.345	0.715	0.390	26.50	0.429	0.350	0.104
8	12.72	0.137	0.111	0.016	25.55	1.132	1.060	0.899
9	18.90	0.188	0.032	0.016	20.80	0.500	0.476	0.191
10	17.20	0.408	0.318	0.239	26.95	0.344	0.016	0.024
11	16.20	0.379	0.732	0.700	26.15	0.364	0.238	0.183
12	12.10	0.255	0.223	0.350	29.00	0.902	1.352	0.414
13	11.09	0.494	0.366	0.239	28.90	0.568	0.572	0.350
14	19.42	0.461	0.366	0.335	26.85	0.785	0.589	0.477
15	12.61	0.916	0.700	0.430	26.00	0.141	0.143	0.199
16	10.15	0.681	0.732	0.653	27.90	1.083	1.143	0.692
17	14.00	0.239	0.238	0.104	26.50	1.001	0.541	0.374
18	14.30	0.277	0.335	0.303	27.95	0.140	0.175	0.024
19	14.19	0.377	0.604	0.533	22.20	0.255	0.271	0.080
20	13.39	0.168	0.286					
21	11.44	0.364						
Average		0.39	0.37	0.38		0.62	0.59	0.37
Years in class		26	27	26		16	17	27
Average annual growth for four years		0.38				0.49		
Average years in class		26				20		

TABLE L.—*Annual diameter growth of Parashorea malaanonan (bagtican lauan) in virgin forest on Mount Maquiling; altitude, about 300 meters*—Continued.

No. of tree in class.	Diameter class in centimeters.							
	30 to 40.				40 to 50.			
	Diameter.	Annual growth.			Diameter.	Annual growth.		
		1913.	1914.	1915 and 1916.		1913.	1914.	1915 and 1916.
1	39.60	1.047	1.033	0.716	45.70	0.859	0.891	0.676
2	36.20	1.536	2.116	1.479	46.80	0.664	1.018	0.923
3	30.40	0.492	0.875	0.255	42.75	0.804	0.646	0.509
4	38.65	1.881	0.621	0.430	44.10	1.110	1.354	1.058
5	33.00	0.318	0.207	0.143	49.25	0.903	1.210	0.955
6	39.00	1.088	0.924	0.978	46.60	0.698	0.748	0.279
7	36.55	0.236	0.175	0.024	45.50	1.071	1.081	0.509
8	34.60	1.058	0.700	0.708	47.50	1.186	1.720	1.742
9	31.65	0.506	0.493	0.327	43.10	0.830	0.907	0.573
10	35.40	1.079	0.954	1.344	44.25	0.455	0.382	0.255
11	33.50	0.949	0.747	0.493	43.40	0.567	0.922	0.366
12	39.75	0.858	0.651	0.708	40.90	0.600	0.684	0.477
13					43.25	0.513	0.541	0.374
14					46.80	1.050	1.142	0.835
15					46.75	1.217	0.794	0.875
16					47.35	0.661	1.241	0.891
17					40.75	1.315	1.064	0.621
18					42.50	1.827	2.039	1.559
19					43.30	0.774	0.779	0.819
20					49.20	0.521	0.604	0.414
21					46.70	0.268	0.620	0.803
22					46.75	0.477	0.589	1.114
23					48.80	1.116	0.668	0.875
24					49.75	0.784	0.604	0.525
25					41.10	0.999	1.098	1.082
26					49.00	1.006	0.573	0.907
27					43.40	0.286	0.700	0.796
28					46.00	0.661	1.044	0.629
Average		0.92	0.79	0.63		0.83	0.92	0.77
Years in class		11	13	16		12	11	13
Average annual growth for four years		0.74				0.82		
Average years in class		13.5				12		

TABLE L.—*Annual diameter growth of Parashorea malaanonan (bagtican lauan) in virgin forest on Mount Maquiling; altitude, about 300 meters*—Continued.

No. of tree in class.	Diameter class in centimeters.							
	50 to 60.				60 to 70.			
	Diameter.	Annual growth. 1913.	1914.	1915 and 1916.	Diameter.	Annual growth. 1913.	1914.	1915 and 1916.
1	54.60	0.366	0.254	0.183	67.10	0.236	0.558	0.581
2	54.90	0.901	1.160	1.169	62.80	0.524	0.858	0.915
3	59.50	0.924	0.700	0.557	64.50	2.140	1.683	0.470
4	54.50	0.593	0.923	0.629	62.70	0.478	0.494	0.327
5	51.15	1.222	1.580	1.209	60.25	0.823	1.018	0.803
6	58.15	1.659	1.353	1.861	60.50	0.674	1.082	1.901
7	57.90	0.532	0.793		63.20	0.344	0.890	0.501
8					67.30	0.028	0.441	
9					64.90	0.276	0.923	0.732
10					62.70	0.478	0.441	
Average		0.89	0.97	0.94		0.60	0.84	0.78
Years in class		11	10	11		17	12	13
Average annual growth for four years		0.94				0.75		
Average years in class		11				13		

No. of tree in class.	Diameter class, 70 to 80 centimeters.			
	Diameter.	Annual growth. 1913.	1914.	1915 and 1916.
1	78.90	0.349	0.921	1.042
Average		0.35	0.92	1.04
Years in class		29	11	10
Average annual growth for four years		0.84		
Average years in class		12		

The measurements taken in January, 1917, were made on the occasion of a hurried trip to Los Baños; a few of the trees previously measured were not relocated, as the band of white paint with which they had been marked four years previously had largely disappeared. This accounts for the blanks in the column for 1915 and 1916.

It will be seen that the same tree frequently shows very different rates of growth in the different years. This may

very well be connected with differences in exposure due to changes in the size of the crowns of the trees composing the canopy. When, however, the average rates for all the trees in a class are calculated, the averages for the different years are much more similar than are the rates for the individuals. Moreover, the total number of years required by a tree to grow from a diameter of 5 centimeters to the largest diameter is very similar for all of the different years. It seems probable, therefore, that the rates of growth calculated in Table L are approximately average rates for *Parashorea* at this altitude on Mount Maquiling.

This does not mean, however, that from these figures we can accurately calculate the ages of trees of small diameters; for, as has already been pointed out, many of the small trees may not reach mature size. This is particularly true of those in the 0- to 5-centimeter class. In Brown and Matthews's Table XVI * in which are presented the rates of growth of *Parashorea* on Mount Maquiling, tree 3 in the 0- to 5-centimeter class showed no growth. At the end of 1914 this tree still appeared healthy, but again showed no growth. In January, 1917, it was found to be dead.

Tree 3, in the 0- to 5-centimeter class in Table L, showed no growth during 1913, but in 1914 grew 0.032 centimeter in diameter and in 1915 and 1916 made an average annual growth of 0.056 centimeter. Tree 1, in the same class in Table L, showed a growth of 0.112 centimeter in 1913, and no growth in 1914. This tree was not relocated in January, 1917, but was observed later when it was apparently vigorous. It will be seen, therefore, that it is not possible to tell by the appearance of a tree or by its rate of growth for a year whether or not it will continue to exist.

The rates shown for the 0- to 5-centimeter class are very varied, as are also the averages for the different years. It is, therefore, probable that there is a considerable error in estimating the age of trees in this class; but this error is not likely to be large enough to produce a very considerable error in estimating the ages of trees of large size.

The average rates of growth of trees in the 5- to 10-centimeter class agree much more closely than do those of trees in the 0- to 5-class, and it seems probable that a calculation from these figures, of the number of years required for a tree

* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

to grow from 5 to 10 centimeters, is fairly close to the actual time involved. The trees in this class are tall enough to be high in the forest.

Trees which are more than 20 centimeters in diameter are in the first story, and the calculations of the number of years required for them to pass through the higher diameter classes should be fairly accurate. In discussing the composition of the dipterocarp forest it was shown that trees even less than 20 centimeters in diameter may be in the first story.

If the rates as calculated above are applicable to the trees in the forest as a whole, then the number of individuals in a diameter class divided by the number of years calculated for a tree to pass through the same diameter class should be practically constant for all classes. Such a calculation based on the number of trees in different diameter classes on a square hectare indicates that there is a very low rate of mortality in trees between 5 and 40 centimeters in diameter, and so the calculations of the rates of growth for diameters above the 0- to 5-class may be regarded as fairly accurate.

While the method of calculating the age of a tree is subject to the error above mentioned, this error does not affect the validity of a comparison of rates of growth of trees of various diameters in different situations, for the measurements represent the actual rates of growth of average trees of different diameters.

In fig. 2 there is presented a curve of the rates of growth of *Parashorea.* In this curve the ordinates represent diameters and the abscissae years. According to the curve, it takes an average individual of *Parashorea* one hundred ninety-seven years to reach a diameter of 80 centimeters. This slow rate of growth is very evidently due to the fact that the trees are suppressed while young; as, according to the curve, it would require seventy-one years for a tree to reach a diameter of 5 centimeters. After the trees have come to be in the main canopy they show a rapid rate of growth.

The following conclusions of Brown and Matthews give a comparison of the rates of growth of *Parashorea* with those of trees in America:

It will be seen from the curves that the rate of growth of white oak is faster than that of *Parashorea,* until the trees are 37.5 centimeters in diameter, while yellow poplar grows faster than *Parashorea* until it attains a diameter of 65 centimeters. Yellow pine in New Mexico and oak on site I in Europe show rates of growth intermediate between white oak and yellow poplar. It is also to be noted that the curve for *Parashorea* crosses those of all of the temperate zone species and in the larger diameter classes lies considerably above them. This shows clearly that in the latter

part of the life of *Parashorea* it is distinctly the fastest growing of all the species here considered. Yellow poplar, the fastest growing of the temperate zone species, takes one hundred fifteen years to grow from 30 centimeters in diameter to 70 centimeters, while *Parashorea* makes the same growth in fifty years. The results would seem to show clearly that only the larger individuals of *Parashorea* are in a position to take advantage of the more favorable conditions for growth which exist in the tropics and that throughout the earlier period of their existence they maintain themselves and grow under very adverse conditions; that is, *Parashorea* in a virgin forest passes through an exceptionally long suppression period as compared with trees in a deciduous forest of the temperate zone.

The figures for the rates of growth of *Parashorea*, as calculated by Brown and Matthews, and as given in Table L, show some slight differences, but not enough to affect the general conclusions reached by them.

Measurements were also begun by Brown and Matthews of fifty individuals of *Parashorea* growing in a pure stand near the base of Mount Maquiling at an altitude of about 100 meters. None of these trees were more than 14 centimeters in diameter. This stand was located at the edge of the forest near a large seed tree, and probably became established under a canopy which has since disappeared. The straggling individuals near

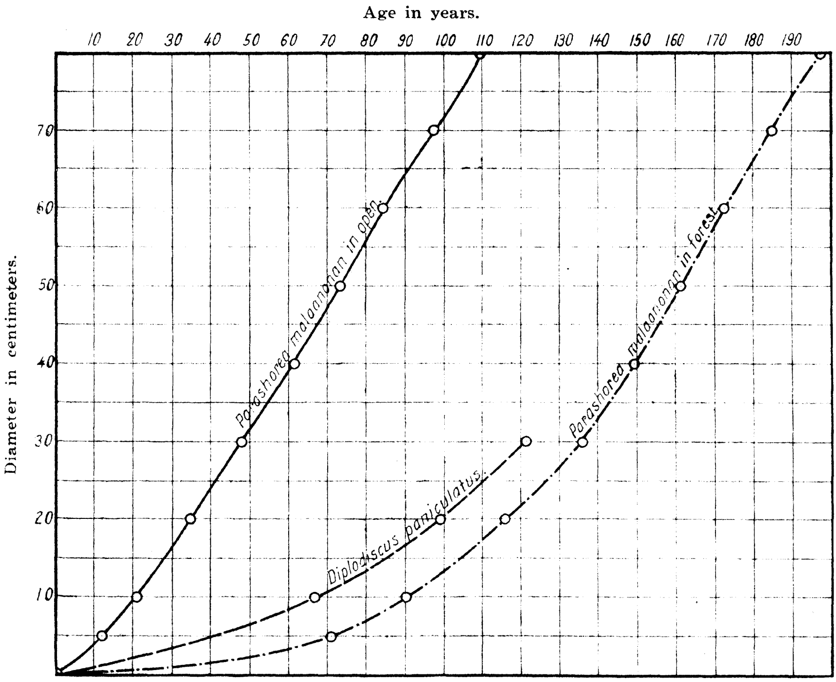

FIG. 2. Rates of growth of trees in dipterocarp forest on Mount Maquiling; altitude, 300 meters.

the edge of the stand were in an exposed situation. They were smaller than those in the main stand and showed a slower rate of growth. While, thus, too great exposure appears to be injurious to young plants of *Parashorea*, the trees growing in a pure stand in the open show a much faster rate of growth than those in the virgin forest. The results of the measurements of these trees are given in Table LI.

TABLE LI.—*Annual diameter growth of Parashorea malaanonan (bagtican lauan) in open at base of Mount Maquiling; altitude, about 100 meters.*

[Diameters and growth are given in centimeters.]

No. of tree in class.	Diameter class in centimeters.								
	0 to 5.			5 to 10.			10 to 15.		
	Diameter.	Annual growth. 1913 and 1914.	Annual growth. 1915 and 1916.	Diameter.	Annual growth. 1913 and 1914.	Annual growth. 1915 and 1916.	Diameter.	Annual growth. 1913 and 1914.	Annual growth. 1915 and 1916.
1	4.95	0.541	0.335	7.10	0.986		10.05	0.557	
2	4.17	0.350		7.60	0.366		13.60	0.883	0.827
3	4.14	0.374		6.15	0.581		13.80	0.756	
4	3.60	0.859		5.15	0.653		10.95	1.034	
5	3.74	0.581		6.04	0.501		10.24	0.297	0.637
6	4.29	0.994		5.39	0.565		10.88	0.780	0.716
7	3.30	0.183	0.191	6.95	0.493		11.10	0.748	0.796
8	4.62	0.398		6.10	0.287				
9	3.43	0.175	0.127	5.15	0.438				
10	4.35	0.454	0.048	5.06	0.740				
11	4.70	0.509		7.35	0.629	0.462			
12	4.92	0.327	0.827	7.37	0.955				
13	4.87	0.462	0.605	6.16	0.467				
14				5.42	0.247	0.063			
15				6.00	0.358	0.112			
16				6.40	0.414	0.589			
17				5.04	0.430	0.653			
18				6.69	0.525	0.859			
19				5.75	0.541	0.159			
20				5.51	0.509				
21				5.02	0.891	0.700			
22				6.63	0.891				
23				5.90	0.875				
24				9.00	0.287	0.621			
25				9.20	0.970	0.939			
26				7.97	0.661	0.501			
27				9.30	0.605	0.438			
Average		0.477	0.356		0.588	0.508		0.722	0.744
Years in class		10.5	14.0		8.5	9.8		6.9	6.7
Average annual growth for four years		0.417			0.548			0.733	
Average years in class		12			9.1			6.8	

The measurements were made at the same times as those of *Parashorea* growing in the forest. Between January, 1915, and January, 1917, many of these trees were cut down so that the number measured in January, 1917, was considerably smaller than on the other dates.

In fig. 2 is also shown a curve for *Parashorea* growing in the open, the rates of growth of the smaller diameters being based on the figures in Table LI, and those for the larger classes, on the figures in Table L. The rate of growth of the 20- to 30-centimeter class was obtained by calculation.

According to Table LI, a tree in the open would require 13.6 years to grow from 10 to 20 centimeters in diameter, and according to Table L a tree would grow from 30 to 40 centimeters in diameter in 13.5 years. A tree 30 to 40 centimeters in diameter in the virgin forest is in the main canopy and so may be regarded as growing in the open. Trees 20 to 30 centimeters in diameter are not so completely exposed and show a slower rate of growth than either the 10- to 20-centimeter class in the open or the 30- to 40-class in the forest. It would seem, however, that, if they were growing fully exposed, they should make as rapid growth as those of the 10- to 20-centimeter class in the open. In calculating the age of the trees in the open the figure 13.5 has been used as the number of years required by a tree to grow from 20 to 30 centimeters. This figure is identical with that for trees 30 to 40 centimeters in diameter in the forest, and only one-tenth of a year faster than that for trees 10 to 20 centimeters in diameter in the open.

It will be seen that the growth as calculated for individuals in the open is very much faster than that for those in the forest as, according to the estimates, a tree 80 centimeters in diameter in the open would be 111 years old, while one in the forest of the same size would have an age of 197 years. The great difference in the rates of growth of young individuals in the open and in the forest is shown very clearly. A tree 20 centimeters in diameter in the open has an estimated age of 35 years, and one in the forest, 116 years.

This shows very clearly that the slow growth of the smaller sizes of *Parashorea malaanonan* in the forest is due to adverse conditions existing under the dense canopy of the first and second story.

Measurements of the growth of *Diplodiscus paniculatus* (balobo) are given in Table LII. These measurements covered the

TABLE LII.—*Annual diameter growth of Diplodiscus paniculatus (balobo) for 1913 and 1914 in dipterocarp forest on Mount Maquiling; altitude, about 300 meters.*

[Diameters and growth are given in centimeters.]

No. of tree in class.	Diameter class in centimeters.					
	0 to 10.		10 to 20.		20 to 30.	
	Diameter.	Growth.	Diameter.	Growth.	Diameter.	Growth.
1	5.00	0.08	10.32	0.07	21.20	0.56
2	5.72	0.03	10.82	0.27	21.40	0.33
3	6.22	0.11	11.72	0.11	21.80	0.58
4	6.30	0.11	11.78	0.31	23.70	0.27
5	6.43	0.05	12.00	0.57	24.15	0.38
6	6.43	0.09	12.10	0.02	24.70	0.57
7	7.10	0.37	12.58	0.08	25.40	0.45
8	7.41	0.04	12.69	0.13	26.35	0.40
9	7.62	0.31	13.19	0.55		
10	7.71	0.16	13.20	0.45		
11	7.91	0.10	13.21	0.25		
12	8.97	0.33	14.55	0.67		
13	9.10	0.18	14.60	0.51		
14	9.80	0.20	14.68	0.25		
15			16.20	0.30		
16			17.38	0.19		
17			17.63	0.52		
18			17.70	0.26		
19			18.30	0.51		
20			18.33	0.15		
Average for 1913 and 1914		0.15		0.31		0.44
Years in class		66.7		32.3		22.7

period between January, 1913, and January, 1915. They were made on approximately the same dates as those for *Parashorea.* The trees were in the same area as the specimens of *Parashorea* measured in the forest. From a comparison of the rates of growth of *Diplodiscus,* as shown in Table LII, with those of *Parashorea* in Table L it will be seen that the rates of growth of *Diplodiscus* are slightly slower than those of *Parashorea.* The rates for *Diplodiscus* as calculated in Table LII are plotted in fig. 2 together with those for *Parashorea.* In this figure the curve for *Diplodiscus* is above that for *Parashorea.* This is very evidently due to the fact that no trees of *Diplodiscus* less than 5 centimeters in diameter were measured, and so the rate of growth of the 0- to 10-centimeter class is based entirely on trees more than 5 centimeters in diameter. Had trees of *Diplodiscus* in the 0- to 5-centimeter class been included in the measurements, the curve for this species would probably lie below that

for *Parashorea,* as we have seen that the larger diameter classes of *Diplodiscus* show a slower rate of growth than those of the same classes of *Parashorea.* Brown and Matthews* found that, in general, second-story species showed a slower rate of growth than the dominant dipterocarps.

The rates of growth for *Dillenia philippinensis* in 1913 and 1914 are given in Table LIII. This species was growing in the same situation as *Parashorea* and *Diplodiscus,* and the measurements were made at the same time as those for *Diplodiscus.* The rates of growth of this species will be discussed later in connection with measurements of the same species growing in the midmountain forest.

TABLE LIII.—*Annual diameter growth of Dillenia philippinensis* (*catmon*) *for 1913 and 1914 in dipterocarp forest on Mount Maquiling; altitude, about 300 meters.*

[Diameters and growth are given in centimeters.]

No. of tree in class.	Diameter class in centimeters.							
	0 to 10.		10 to 20.		20 to 30.		30 to 40.	
	Diameter.	Growth.	Diameter.	Growth.	Diameter.	Growth.	Diameter.	Growth.
1	8.0	0.46	15.1	0.55	20.0	0.35	33.9	0.24
2					22.3	0.43		
3					22.5	0.42		
4					27.9	0.17		
5					28.1	0.44		
6					29.5	0.53		
Average annual growth		0.46		0.55		0.39		0.24
Years in class		22		18		26		42

GROWTH IN THE MIDMOUNTAIN FOREST

Measurements of growth in the midmountain forest were made at an elevation of 740 meters and included three species: *Astronia pulchra,* which, as before mentioned, is the dominant species in a limited area at this elevation; *Dillenia philippinensis* (catmon), a second-story tree; and *Dillenia reifferscheidia* (catmon carabao), another second-story species. The trees were located in the immediate neighborhood of the station at which

* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

measurements were made of the environmental factors. This station is shown on the map, Plate XLI, as station 4.

The first measurement was taken January 23, 1913, and subsequent measurements on about the same date in January, 1914, 1915, and 1917. The rates of growth of *Astronia pulchra* for these different periods are given in Table LIV. As was the case with *Parashorea*, the same trees frequently showed very different rates of growth for the different years. The average rates of growth for the whole period are plotted in fig. 3.

TABLE LIV.—*Annual diameter growth of Astronia pulchra in midmountain forest on Mount Maquiling; altitude, 740 meters.*

[Diameters and growth are given in centimeters.]

No. of tree in class.	Diameter class in centimeters.							
	0 to 10.				10 to 20.			
	Diameter.	Annual growth.			Diameter.	Annual growth.		
		1913.	1914.	1915 and 1916.		1913.	1914.	1915 and 1916.
1	7.8	0.03	0.31	0.18	17.9	0.22	0.30	0.30
2	9.8	0.03	0.01		17.6	0.36	0.28	0.35
3	7.3	0.01	0.05	0.11	15.6	0.39	0.15	0.03
4					17.7	0.27	0.17	0.10
5					18.0	0.18	0.12	0.08
6					14.8	0.00	0.00	0.06
7					14.1	0.00	0.00	0.03
8					17.8	0.01	0.03	0.00
9					19.5	0.04	0.08	0.02
10					18.9	0.43	0.45	0.16
11					18.3	0.54	0.44	0.19
12					13.6	0.21	0.00	0.08
13					12.5	0.04	0.00	0.00
14					13.5	0.00	0.00	0.03
15					18.4	0.21	0.23	0.11
16					15.1	0.15	0.03	0.14
17					15.7	0.27	0.41	0.29
18					12.8	0.22	0.18	0.03
19					14.2	0.00	0.18	0.08
20					12.5	0.00	0.10	0.02
21					13.2	0.12	0.04	0.05
Average		0.02	0.12	0.15		0.17	0.15	0.10
Years in class		500.0	83.3	66.7		58.8	66.7	100.0
Average annual growth for four years		0.11				0.13		
Average years in class		90.9				76.9		

TABLE LIV.—*Annual diameter growth of Astronia pulchra in midmountain forest on Mount Maquiling; altitude, 740 meters*—Continued.

No. of tree in class.	Diameter class in centimeters.							
	20 to 30.				30 to 40.			
	Diameter.	Annual growth.			Diameter.	Annual growth.		
		1913.	1914.	1915 and 1916.		1913.	1914.	1915 and 1916.
1	26.9	0.24	0.34	0.29	36.5	0.25	0.13	0.23
2	21.6	0.22	0.38	0.40	33.2	0.30	0.36	0.25
3	24.5	0.13	0.05	0.15	32.7	0.43	0.47	0.27
4	28.2	0.31	0.49	0.38	34.7	0.12	0.36	0.25
5	21.5	0.06	0.10	0.14	35.4	0.63	0.63	0.63
6	27.7	0.16	0.34	0.41	34.2	0.57	0.45	0.62
7	20.2	0.54	0.32	0.18	31.7	0.22	0.18	0.21
8	22.6	0.27	0.33	0.14				
9	24.0	0.30	0.34	0.19				
10	29.3	0.30	0.32	0.23				
11	27.3	0.10	0.14	0.23				
12	28.5	0.24	0.26	0.31				
13	25.0	0.03	0.13	0.08				
14	29.4	0.25	0.65	0.03				
15	23.1	0.09	0.09	0.06				
16	27.2	0.21	0.31	0.19				
17	22.7	0.18	0.28	0.18				
18	25.9	0.55	0.53	0.41				
19	21.2	0.36	0.34	0.21				
Average		0.24	0.30	0.22		0.36	0.37	0.35
Years in class		41.7	33.3	45.5		27.8	27.0	28.6
Average annual growth for four years		0.25				0.36		
Average years in class		40.0				27.8		

No. of tree in class.	Diameter class, 40 to 50 centimeters.			
	Diameter.	Annual growth.		
		1913.	1914.	1915 and 1916.
1	48.9	0.36	0.56	0.40
Average		0.36	0.56	0.40
Years in class		27.8	17.9	25.0
Average annual growth for four years		0.43		
Average years in class		23.3		

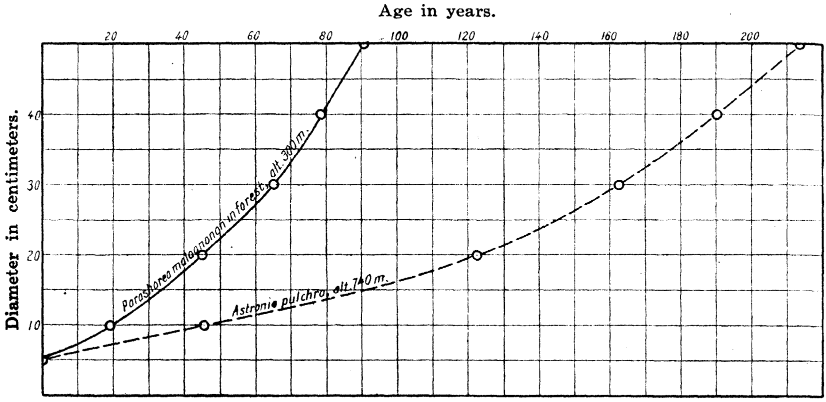

FIG. 3. Diameter growth of *Parashorea* at 300 meters', and *Astronia pulchra* at 740 meters' altitude.

As no measurements were obtained of trees less than 5 centimeters in diameter, the curve in fig. 3 has been plotted to show the number of years required for an average tree to grow from 5 centimeters to larger diameters up to 50 centimeters, and in the same figure there is also plotted a similar curve for *Parashorea malaanonan* at an altitude of 300 meters. A comparison of these curves shows that, whereas *Parashorea malaanonan* requires about ninety years to grow from 5 to 50 centimeters, *Astronia pulchra* takes two hundred thirteen years to make the same growth. Both of these species may be regarded as being in the same story when they are more than 20 centimeters in diameter. It may, therefore, be more accurate to compare the rates of growth of these species for diameters of between 20 and 50 centimeters. *Parashorea* makes this growth in forty-five and one-half years, while *Astronia* requires ninety-one years or twice as long as *Parashorea.* This difference in rate of growth is roughly proportionate to the greatest height attained by the two species at the altitudes concerned, for at 300 meters' elevation *Parashorea* attains a height of about 38 meters, while *Astronia pulchra* at 740 meters grows to a height of about 20 meters.

TABLE LV.—*Annual diameter growth of Dillenia philippinensis in mid-mountain forest on Mount Maquiling; altitude, 740 meters.*

[Diameters and growth are given in centimeters.]

No. of tree in class.	Diameter class in centimeters.							
	0 to 10.				10 to 20.			
	Diameter.	Annual growth.			Diameter.	Annual growth.		
		1913.	1914.	1915 and 1916.		1913.	1914.	1915 and 1916.
1	8.3	0.19	0.09	0.21	14.9	0.10	0.22	0.14
2	5.5	0.07	0.17	0.18				
Average		0.13	0.13	0.20		0.10	0.22	0.14
Years in class		76.9	76.9	50.0		100.0	45.5	71.4
Average annual growth for four years		0.17				0.15		
Average years in class		59				67		

No. of tree in class.	Diameter class, 20 to 30 centimeters.			
	Diameter.	Annual growth.		
		1913.	1914.	1915 and 1916.
1	20.2	0.18	0.20	0.11
2				
Average		0.18	0.20	0.11
Years in class		55.6	50.0	90.9
Average annual growth for four years		0.15		
Average years in class		67		

TABLE LVI.—*Annual diameter growth of Dillenia reifferscheidia in mid-mountain forest on Mount Maquiling; altitude, 740 meters.*

[Diameters and growth are given in centimeters.]

No. of tree in class.	Diameter class in centimeters. 10 to 20. Diameter.	10 to 20. Annual growth. 1913.	1914.	1915 and 1916.	20 to 30. Diameter.	20 to 30. Annual growth. 1913.	1914.	1915 and 1916.
1	14.3	0.10	0.16	0.08				
2					25.1	0.33	0.23	0.16
Average		0.10	0.16	0.08		0.33	0.23	0.16
Years in class		100.0	62.5	125.0		30.3	43.5	62.5
Average annual growth for four years		0.11				0.22		
Average years in class		91				45		

In Table LV the rates of growth for *Dillenia philippinensis* are given, and in Table LVI those for *Dillenia reifferscheidia*. The results are plotted in fig. 4, together with those for *Dillenia philippinensis* at an altitude of 300 meters. From these figures it will be seen that at an altitude of 740 meters *Dillenia philippinensis* and *Dillenia reifferscheidia* have about the same rate

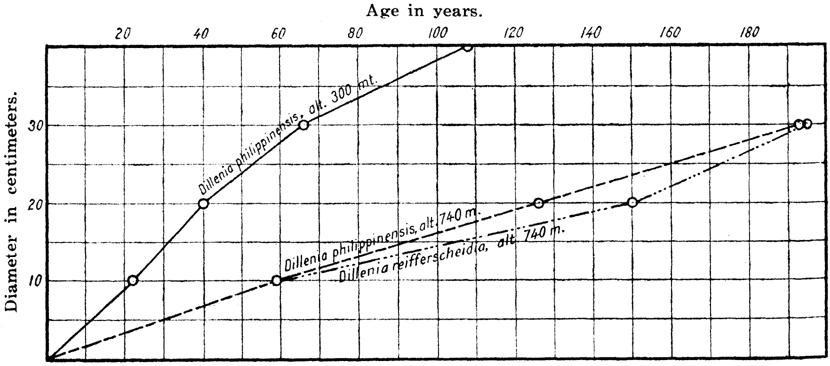

FIG. 4. Rates of growth of *Dillenia* at altitudes of 300 and 740 meters.

of growth, and that this rate is much slower than that for *Dillenia philippinensis* at 300 meters. According to the curves in this figure, *Dillenia philippinensis* at an altitude of 300 meters attains a diameter of 30 centimeters in sixty-six years, while at 740 meters it requires one hundred ninety-three years to reach the same diameter. The figures on which these curves are based are not numerous enough to permit any exact com-

parison, but they indicate very clearly that at high altitudes *Dillenia* grows much more slowly than at low elevations.

GROWTH IN MOSSY FOREST

Owing to the irregular shapes of the tree trunks and the great development of the aërial roots, it is impracticable to measure the diameter growth of most of the trees in the mossy forest. For this reason the second-growth species, *Homalanthus alpinus*, was selected for measurement. This tree, as previously pointed out, invades open places that are caused by the death or removal of trees forming the canopy of the mossy forest. At an altitude of about 1,000 meters there was a small area in which *Homalanthus alpinus* formed a very open, pure stand. Measurements of individuals in this area were made on January 16, 1913, and about the same date in January, 1914 and 1915. The results are presented in Table LVII.

TABLE LVII.—*Annual diameter growth of Homalanthus alpinus in mossy forest on Mount Maquiling; altitude, about 1,000 meters.*

[Diameter and growth are given in centimeters.]

No. of tree in class.	Diameter class in centimeters.					
	0 to 10.			10 to 20.		
	Diameter.	Growth.		Diameter.	Growth.	
		1913.	1914.		1913.	1914.
1	5.1	0.21	0.23	10.1	0.61	0.55
2	5.3	0.06	0.04	10.2	0.76	0.34
3	5.7	0.06	0.00	10.9	0.43	0.29
4	6.0	0.25	0.43	11.6	0.18	0.38
5	6.2	0.16	0.08	14.0	0.18	0.24
6	6.3	0.52	0.92			
7	6.4	0.00	0.04			
8	6.6	0.00	0.20			
9	7.0	0.04	0.04			
10	7.3	0.34	0.14			
11	7.4	0.09	0.09			
12	7.5	0.28	0.70			
13	7.8	0.77	0.69			
14	8.1	0.27	0.13			
15	8.2	0.03	0.11			
16	8.2	0.13	0.21			
17	8.5	0.63	1.95			
18	8.6	0.15	0.65			
19	9.5	0.13	0.47			
20	9.7	0.28	0.20			
Average		0.22	0.37		0.43	0.36
Average for 1913 and 1914		0.29			0.39	
Years in class		34			26	

There were no trees in this area less than 5 centimeters in diameter, and so the figures for the 0- to 10-centimeter class are based on trees measuring more than 5 centimeters in diameter. The average annual rate of growth of trees in the 0- to 10-centimeter class was 0.29 centimeter, and in the 10- to 20- class, 0.39 centimeter. From these figures it was calculated that a tree would require thirty-four years to reach a diameter of 10 centimeters, and twenty-six years to grow from 10 to 20 centimeters.

In fig. 5 the rates of growth of *Homalanthus alpinus* at an elevation of about 1,000 meters are compared with the average rates of growth of second-growth species at the base of Mount Maquiling, at an altitude of about 80 meters. As no trees of *Homalanthus* less than 5 centimeters in diameter were measured, the curves in fig. 5 are drawn to show the rates of growth from a diameter of 5 to one of 20 centimeters. In the figure are shown separately the average rates of growth of second-growth trees that reach a diameter of more than 20 centimeters and

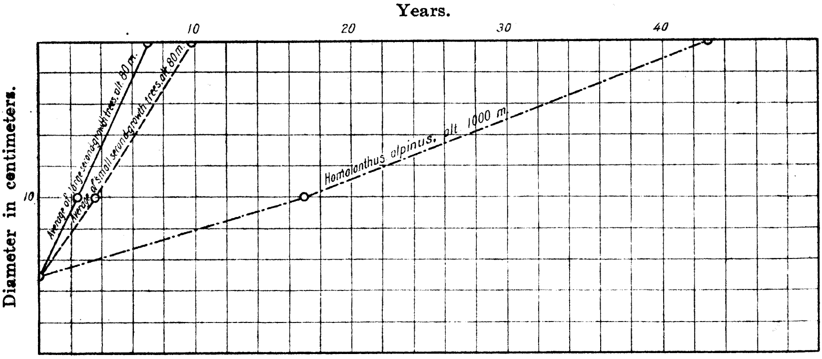

FIG. 5. Rates of growth of second-growth trees on Mount Maquiling at altitudes of 80 and 1,000 meters.

of those that do not reach a diameter of 20 centimeters. As *Homalanthus* is a small tree, it may perhaps be best compared with the average of the smaller second-growth species at an altitude of 80 meters. According to the curve in fig. 5, the average small second-growth tree at an altitude of 80 meters requires about ten years to grow from 5 to 20 centimeters, while *Homalanthus* requires forty-three years to make the same growth. This difference in rate is probably greater than the difference in the height of the canopy of the forest which formerly existed at 80 meters, and that which is now found at 1,000 meters; as at the lower elevation trees may have reached a

height of about 45 meters, while at 1,000 meters the tallest ones are about 14 meters in height.

CONCLUSIONS

A comparison of the rates of growth of trees in the dipterocarp with those in the midmountain forest, and of those in the second-growth at 80 meters with the second-growth tree *Homalanthus alpinus* at 1,000 meters would seem to indicate that the rates of growth are roughly proportionate to the heights of the virgin forests at different altitudes. Such a conclusion as this can of course only be accepted in the most general terms, as it is well known that trees of different species, even though they reach about the same size, may show different rates of growth. It would seem, however, that the much slower rate at which trees grow at high than at low altitudes on Mount Maquiling may very well be connected with the dwarfing as higher altitudes are reached; and, if we assume that the trees have approximately equal lengths of life, this would certainly be sufficient to account for the dwarfing at high altitudes.

Trees at all altitudes are subject to fungus attacks; and, as they reach their largest size, the trunks become hollow; this is apparently just as true of trees at high as at low altitudes. The lower temperature at high altitudes would, in all probability, retard the rate of growth of fungi; but, as the trees are smaller at high altitudes, there is no reason for supposing that fungi would not grow in them just as fast in proportion to their size as they would in larger trees at lower elevations.

We have previously seen that on the steeper slopes trees are smaller than in more level places and that in the first case the small size may be connected with erosion; but even on level areas dwarfing is pronounced, and the measurements given in this paper for heights at different elevations were recorded from trees growing in level situations or on gentle slopes.

We may, therefore, tentatively conclude that the smaller size of the trees at high elevations is connected, to a large extent at least, with the slow rate of growth. If the slow growth at the higher altitudes is not directly responsible for the small size of the trees, the same factors that limit the rates of growth may also limit the size attained.

Dr. F. T. MacLean informs me that while working on aspen he found that, if a tree were subnormal in height while attaining its growth in height, it would be subnormal in height at maturity and, moreover, the degree of dwarfing at a given age would be proportional to the height of the tree when mature. This affords some evidence that rates of growth in height may be roughly proportional to the heights of trees when mature.

Further evidence on this point is afforded by a comparison of the rates of growth of trees on Mount Maquiling with other species growing on other mountains. Brown * has made a study of the rates of growth of *Podocarpus* on Mount Banahao at an altitude of 2,100 meters. *Podocarpus* at this altitude reaches a height of about 14 meters, while the average height of the main canopy, composed entirely of *Podocarpus*, is about 12 meters. These trees are much shorter than *Astronia pulchra* on Mount Maquiling, and the rate of growth is much slower. According to the figures in Table LIV an individual of *Astronia pulchra* 50 centimeters in diameter would be 259 years old while, according to the curve given by Brown, *Podocarpus* at the top of Mount Banahao would require 444 years to reach the same size. The measurements in these two cases are comparable, as in both cases the smallest trees measured were in the 5- to 10-centimeter class. Here again the rates of growth are approximately proportional to the size of the trees.

Koorders,† in studying the forest at an altitude of about 1,500 meters on the Gedeh in Java, measured a tree of *Altingia excelsa* 49 meters in height. Brown and Yates ‡ found that the trees in this forest grow about as rapidly as those in the tall dipterocarp forests at low altitudes in the Philippines. Brown and Matthews § have further shown that trees in tall dipterocarp forests at low altitudes made a faster growth than those in lower forests at higher altitudes.

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* Brown, W. H., The rate of growth of Podocarpus imbricatus at the top of Mount Banahao, Luzon, Philippine Islands, *Phil. Journ. Sci., Sec. C* (1917), 12, 317–329.

† Koorders, S. H., Floristischer Ueberblick über die Blütenpflanzen des Urwaldes von Tjibodas auf dem Vulkan Gede in West-Java nebst einer Numerliste und einer systematischen Uebersicht der dort für botanische Untersuchungen von mir numerierten Waldbäume, *Engl. Bot. Jahrb.* (1914), 50, Suppl., 278–303.

‡ Brown, W. H., and Yates, H. S., The rate of growth of some trees on the Gedeh, Java, *Phil. Journ. Sci., Sec. C* (1917), 12, 305.

§ Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413–561.

CHEMICAL AND PHYSICAL COMPOSITION OF THE SOIL AT DIFFERENT ELEVATIONS

The composition of the soil at different elevations on Mount Maquiling has been studied by Brown and Argüelles.* The soil of Mount Maquiling is of volcanic origin. An account of the geology has been given by Abella.†

On the lower slopes there are layers of soft volcanic tuff. At elevations of from 50 to 100 meters these layers of tuff, which are mixed with layers of soil, may be many meters thick and are frequently near the surface. The layers near the surface, however, are usually thin, soft, and very much broken. Such a layer, about 30 centimeters thick, is frequently found about 30 centimeters below the surface, and traces occur at elevations above 300 meters. West and Cox ‡ give analyses of a number of samples of similar tuff. These analyses indicate that the tuff should disintegrate into a fertile soil. Where the surface layers of the tuff are shallow and much broken, they appear to have little if any effect in determining the character of the vegetation. No thick layers of tuff have been observed except around the base of the mountain, where the original vegetation has been almost entirely removed.

Except around the base the soil is deep on all parts of the mountain, and rock outcrops are very scarce except in the beds of streams. It was thought at first that the soil near the top might be shallow, and in order to test the depth at the summit of the east peak a soil auger was sunk into the soil to the depth of a meter in a large number of places without anywhere encountering rock.

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* Brown, W. H., and Argüelles, A. S., The composition and moisture content of the soils in the types of vegetation at different elevations on Mount Maquiling, *Phil. Journ. Sci., Sec. A* (1917), **12**, 221–233.

† Abella y Casariego, D. E., El Monte Maquilin. Madrid (1885).

‡ West, A. P., and Cox, A. J., Burning tests of Philippine Portland cement raw materials, *Phil. Journ. Sci., Sec. A* (1914), **9**, 79.

The chemical composition of the soil at different elevations, as given by Brown and Argüelles,* is presented in Table LVIII.

TABLE LVIII.—*Chemical analyses of soils from Mount Maquiling.*

[Water-free basis; numbers give percentages.]

	Source of soil.			
	Grass-land.	Diptero-carp forest.	Mid-moun-tain forest.	Mossy forest.
Loss on ignition	10.32	10.08	13.56	29.97
Nitrogen (N_2)	0.150	0.137	0.199	0.644
Phosphoric anhydride (P_2O_5)	0.278	0.106	0.104	0.112
Lime (CaO)	0.86	1.01	0.31	0.52
Magnesia (MgO)	0.62	0.61	0.49	0.79
Potash (K_2O)	0.294	0.241	0.189	0.170
Soda (Na_2O)	0.37	0.44	0.53	0.34
Humus	1.36	1.06	1.71	8.06
Soil acidity ($CaCO_3$ equivalent)	0.0069	0.0100	0.0094	0.0082

The sample from the grassland was taken on the ridge at station 1, at an elevation of about 100 meters; that from the dipterocarp forest, at station 2, at an elevation of 300 meters; that from the midmountain forest, at station 4, at an elevation of about 740 meters; and that from the mossy forest, at station 5, at an elevation of 1,050 meters. From the table it will be seen that none of the soils is strikingly deficient in any important element, and none can be considered as acid. The amount of nitrogen and humus is greatest in the mossy forest, where the vegetation is most dwarfed. It is to be noted that the smallest amount of nitrogen and humus is shown by the sample from the tall dipterocarp forest. The chemical analyses of the soil, as shown in Table LVIII, do not indicate that there is any connection between its chemical composition and the dwarfing of the vegetation as higher elevations are reached.

The physical analyses of the soils, as given by Brown and Argüelles,† are presented in Table LIX. There is nothing in these analyses to indicate that the soils should not all produce a luxuriant type of vegetation. If any distinction can be made it seems that the soil of the mossy forest should be the best, as it is a fine, sandy loam, while that of the dipterocarp forest and grassland is a loamy clay.

* Loc. cit.

† Loc. cit.

TABLE LIX.—*Mechanical analyses of soils from Mount Maquiling.*

[Water-free basis; numbers give percentages.]

Classification of soil.	Diameter of particles.	Source of soil.			
		Grass-land.	Dipter-ocarp forest.	Mid-moun-tain forest.	Mossy forest.
	mm.				
	Over 2	nil	nil	nil	nil
	2 to 1	0.9	0.5	0.7	nil
Coarse sand	1.0 to 0.5	2.2	1.3	0.9	5.9
Medium sand	0.5 to 0.25	5.4	4.5	4.1	23.3
Fine sand	0.25 to 0.10	12.5	9.8	8.8	31.4
Very fine sand	0.10 to 0.05	10.8	7.8	12.3	13.2
Silt	0.05 to 0.01	13.6	13.5	4.9	11.2
Very fine silt	0.01 to 0.002	36.5	41.7	39.4	9.4
Clay	Less than 0.002	19.0	21.4	29.6	5.6

The chemical analyses do not indicate the amount of material available for plants, as soils from which soluble constituents have been largely leached out might still show a high percentage of necessary elements, these elements being in a form not readily available for plants. There is, however, no reason for thinking that the soil in the low type of vegetation, at the top of the mountain, is leached out to a greater extent than at other elevations, as the rainfall at the top is no heavier than in the dipterocarp forest at 300 meters' elevation, and not so heavy as in the dipterocarp forest at 450 meters' elevation or in the midmountain forest at an altitude of 740 meters. It also seems improbable that any considerable amount of dissolved matter is carried from the top of the mountain to the high ridges on which the vegetation was measured. These are never flooded but, on the contrary, the streams are confined to deep and narrow valleys. The soil in all of the virgin types of vegetation is always comparatively moist, while the streams increase in size as they flow down the mountain. This would indicate that little, if any, dissolved matter which comes from near the top of the mountain is conveyed from the drainage to the ridges at lower elevations by water carried by capillary attraction.

There is, moreover, no reason for considering one type as being better drained or aërated than another, as the mountain is cut up into ridges and valleys, thus assuring good drainage. The only obvious difference in the various types of vegetation that we might expect would be connected with the character of

the soil is the difference in the height of the trees at different elevations. But there appears to be nothing in the character of the soil that would indicate that it is responsible for this difference.

The shallow nature of the soil at the base of the mountain might lead us to believe that this soil would be the poorest for plant growth; but we find that plants in this soil make an exceedingly rapid growth, and the remnants of the original vegetation which are now to be found there indicate that it was originally covered by a tall forest.

GENERAL REMARKS ON RECORDS OF MEASUREMENTS

LOCATION OF STATIONS

The measurements of environmental factors were taken at five different stations at different altitudes, as shown on the map (Plate XLI).

Station 1 was on a ridge in the parang. The majority of the instruments at this station were placed at a short distance from the buildings of the division of investigation of the Bureau of Forestry as located in 1912. These were at the front of a long, broad ridge on the right of Molauin River. The instruments were scattered for a considerable distance along this ridge, so that they might be in different types of vegetation. The altitudes varied from 75 to about 100 meters.

Station 2 was in the dipterocarp forest at an altitude of about 300 meters and was on the top of a ridge, on the left of Molauin River. One evaporimeter was placed in a ravine a few meters from the bank of Molauin River, at about the point where the trail up the mountain comes nearest to the river. From the map it will be seen that this was some little distance from the main station. This evaporimeter was also at an elevation of 300 meters.

Station 3 was also in the dipterocarp forest and at an elevation of 450 meters. This station, like the others, was on a ridge. The clearing on plot 2, which was at the same elevation, was used to measure conditions in the open at this altitude.

Station 4 was on a ridge in the midmountain forest at an altitude of 740 meters. A ravine is located on the left of the ridge, and one evaporimeter was placed in this ravine about 30 or 40 meters below the elevation of the main station.

Station 5 was in the mossy forest on the summit of the east peak of Mount Maquiling.

DATES OF MEASUREMENTS

The installation of the instruments at the various stations was begun in October, 1911, and as soon as any instrument was installed weekly readings of that instrument were begun. As considerable time was required to make these installations

the readings were not all begun at the same time. At first readings were always taken on Saturday, but of course at different hours of the day, as it was impossible to read the instruments at different stations at anything approximating the same hour. As more instruments were installed, it became impossible to read them all on the same day. Most of the readings for stations 1 and 2 were then taken on Friday afternoon, and those for the other stations on Saturday. At station 3 the instruments were not installed until July, 1913. After this two whole days were occupied in taking readings. Beginning July, 1913, daily readings were also taken with a large number of instruments at station 1 in the immediate neighborhood of the forestry buildings. After this the instruments at station 1, which were read once a week, were read on Friday morning; those at station 2, later on the same day; and those at station 3, on Friday afternoon. The readings for stations 4 and 5 were recorded on Saturday; those for station 4 being taken in the morning, and those for station 5, about midday or early in the afternoon. However, in order that the readings at the different stations might be readily compared without the inconvenience of using different dates, a common date for all was adopted; and, no matter at what time the readings were taken, the week has been regarded as ending on Friday at midnight.

FORM OF RECORDS

As most of the readings were taken weekly, the tables have been calculated for weeks ending Friday at midnight, and the data then assembled in the form of averages, totals, and maxima and minima for four-week periods. These four-week periods for the different years of course ended on different days of the month. Thus, the period ending December 6, 1912, would correspond with the periods ending December 5, 1913, and December 4, 1914, respectively. The averages, totals, and maxima and minima for corresponding four-week periods were then calculated for the entire period from October, 1912, to January 1, 1915, the dates used being those for 1913. The figures in the tables to follow represent the weekly readings from October, 1912, to January 1, 1915, and the data for corresponding four-week periods for the three years. The data for the four-week periods of the single years have been omitted, as the readings for the two years proved to be very similar. All of the data in the different tables have been calculated at least twice, and the results compared. It is believed, therefore, that the results are about as accurate as could be expected.

It is usually customary to give records of temperature and relative humidity according to calendar months. As the data from Mount Maquiling are presented for periods of four weeks rather than for calendar months it has seemed desirable, for purposes of comparison, to prepare summary tables of the data obtained from the recording instruments in the more usual form of calendar months. Such tables are presented in the appendix.

PRESENTATION OF RESULTS

The results of the measurements taken on Mount Maquiling have been recorded in considerable detail. This has been deemed advisable, as the records are much more extensive than any that have been previously given for conditions obtaining in tropical vegetation. It is believed they will be of value in presenting an actual picture of environmental conditions, and they may be of service in the future in interpreting the relation of environment to different types of tropical vegetation in a more exact manner than is now possible.

The method used by some writers, of presenting their results only in the form of curves or of curves with the addition of very short general statements or concise summaries, usually brings out very clearly the points emphasized in the paper; but it does not make the results readily usable for comparison by other workers. In preparing the present paper the writer has seen a number of articles the results of which it would have been very interesting to compare in some detail with those here presented, but to do so was impracticable owing to the methods of presentation just mentioned.

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TEMPERATURE

Two kinds of instruments were used to record temperature; namely, recording thermometers, and maximum and minimum thermometers. The recording thermometers were placed in wooden cases with open bottoms and louvre sides and were about 75 centimeters above the ground. The cases were placed under the forest in all instances, except at 450 meters' elevation, where there were two cases—one under the forest and the other in the open. The records from the recording thermometers are presented in the form of maxima, minima, means, averages of daily maxima, and averages of daily minima.

The means were taken from the original records by a planimeter. This method is very accurate when used in conjunction with the oblong sheets of a Richard Fréres recording thermometer, the type of thermometer used at the base of the mountain where variations in temperature are greatest. At elevations of 300 meters and more the records were obtained from Draper recording thermometers. As the records from these instruments are circular, this method produces an error due to the fact that the area per degree varies with different temperatures. This error would be considerable if the difference between the daily maximum and minimum temperatures were great, and if the maximum and minimum temperatures were maintained for a considerable portion of the day. However, as the average daily variation in temperature on Mount Maquiling was in no situation where circular records were used more than 3.4° C., and as the maxima and minima were maintained for only very short periods, this error becomes negligible. The records used read in Fahrenheit, and the results were converted to centigrade. If a temperature of 80° F. were maintained for one-half of each day in the week, and a temperature of 70° F. for the other half, then the error in calculating the mean with a planimeter would amount to considerably less than 0.2° C. Such a case would be extreme, as a daily variation of 10° F. is much greater than the average daily variation recorded for any situation on Mount Maquiling, where circular records were used. Moreover, the maximum and minimum temperatures are only maintained for very short periods of time, so that the error for a range of 10° F. would be much less than that just

calculated. The error due to the use of a planimeter with the records on Mount Maquiling should be a fraction of a tenth of a degree and therefore a negligible quantity.

The maximum and minimum thermometers were placed in the tops of trees at the different elevations and also in the crowns of second-story trees in the dipterocarp forest at 300 and at 450 meters' elevation. In most cases they were in large boxes with perforated bottoms and with holes in the tops and so fixed as to permit free movement of air without exposure to direct sunlight. The thermometer in the top of the second-story tree at the base was suspended under a ∧-shaped top, without bottom or sides. These instruments probably recorded the minimum temperature accurately, but the maximum may very well have been affected to some extent by radiation. However, a comparison of the temperatures at the tops of the trees at 450 meters' elevation and in the case in the open at the same elevation would indicate that radiation did not raise the temperature recorded by these thermometers to any very considerable extent.

In the following discussion all temperatures are given in degrees centigrade.

TEMPERATURE IN THE PARANG

The taking of temperature records at the base of Mount Maquiling was begun by Dr. F. W. Foxworthy in October, 1911. These records were made with a Richard Fréres recording thermometer, which at first was placed in a very open room in a bamboo house. Later, when the writer began recording climatic data on Mount Maquiling, Doctor Foxworthy transferred this instrument to a case which was placed under a canopy of second-growth trees, where Doctor Foxworthy continued to take records until June, 1913, when the instrument was turned over to the writer. A comparison of simultaneous records taken in an open bamboo house and under the second-growth trees has shown that the temperatures in the two places are very similar, and so the earlier records taken by Doctor Foxworthy have been included in the tables for temperatures under the second-growth trees at the base of Mount Maquiling at an elevation of 80 meters. The recording of temperatures in this situation was continued until January 1, 1915. The results are presented in Table LX in the form of weekly maxima, weekly minima, means, and averages of daily maxima and minima. The figures in Table LX are summarized for corresponding four-week periods for the different years in Table LXI.

TABLE LX.—*Temperature for weekly periods under second-growth trees near the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give degrees centigrade.]

Week ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
1911.					
October 6	32.3	23.1	26.7	31.8	23.9
October 13	31.1	22.9	26.7	30.3	23.5
October 20	31.3	23.0	25.3	29.1	23.3
October 27	31.6	21.6	25.0	29.0	22.6
November 3	30.1	21.1	26.7	29.6	23.0
November 10	30.3	19.9	26.0	29.1	21.8
November 17	29.1	21.1	26.0	28.7	22.4
November 24	29.6	21.6	25.0	28.1	22.5
December 1	29.6	20.0	25.0	28.5	21.7
December 8	29.9	21.9	26.2	28.9	22.8
December 15	31.9	20.3	25.0	29.4	22.9
December 22	29.1	21.8	24.1	28.2	22.5
December 29	28.8	20.3	24.1	28.2	21.6
1912.					
January 5	29.0	20.5	25.0	27.5	21.5
January 12	28.0	20.0	24.6	27.0	21.4
January 19	28.1	20.2	24.6	27.8	20.9
January 26	29.0	19.4	24.3	27.7	20.6
February 2	28.6	19.9	24.0	27.0	20.9
February 9	28.2	19.9	23.6	26.0	20.7
February 16	29.0	19.8	25.5	28.4	21.5
February 23	31.5	21.0	25.5	28.7	22.7
March 1	30.7	20.7	26.4	29.8	21.9
March 8	31.0	20.7	26.2	30.0	21.6
March 15	33.7	21.0	26.7	32.3	22.5
March 22	31.7	21.1	26.0	30.0	22.0
March 29	32.0	21.5	27.0	30.8	22.5
April 5	31.5	21.9	26.2	30.6	22.6
April 12	33.7	22.0	27.0	32.3	23.2
April 19	32.0	22.5	27.4	31.1	23.2
April 26	32.6	23.1	28.1	32.2	23.7
May 3	33.6	22.4	28.0	32.6	24.5
May 10	33.9	22.3	27.1	32.2	23.5
May 17	34.2	22.5	28.3	33.0	23.5
May 24	34.4	22.7	27.6	32.5	24.0
May 31	33.1	23.0	27.1	32.3	23.9
June 7	33.0	22.7	28.0	32.1	24.2
June 14	31.4	22.4	25.2	29.7	22.7
June 21	33.6	22.1	26.4	31.9	22.9
June 28	32.7	21.9	26.7	31.7	22.7
July 5	32.1	21.9	26.0	31.3	23.4
July 12	32.0	22.5	26.0	30.3	23.2
July 19	31.0	22.4	25.0	28.4	23.2

TABLE LX.—*Temperature for weekly periods under second-growth trees near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1912.					
July 26	30.0	21.9	26.4	28.6	22.9
August 2	28.1	20.9	23.6	25.9	22.2
August 9	28.1	20.6	23.2	27.5	21.1
August 16	27.1	20.2	26.0	26.1	20.7
August 23	30.0	22.7	28.0	28.8	23.3
August 30	28.1	21.4	25.3	27.1	22.8
September 6	30.2	20.3	25.1	27.3	21.7
September 13	30.7	21.3	25.3	28.6	23.1
September 20	30.2	22.8	26.0	29.4	24.6
September 27	30.8	22.9	27.0	29.7	23.6
October 4	30.4	22.6	25.5	28.5	23.6
October 11	29.1	22.5	26.0	27.7	23.1
October 18	29.9	22.1	25.0	27.6	23.3
October 25	29.0	22.0	25.5	27.6	23.4
November 1	30.6	22.0	26.2	29.1	23.4
November 8	29.2	22.9	26.0	27.9	23.5
November 15	29.0	22.9	26.0	28.1	23.5
November 22	29.5	22.7	25.5	28.3	23.2
November 29	29.0	22.6	25.0	27.1	23.4
December 6	29.0	22.1	25.3	28.0	22.8
December 13	28.0	20.1	24.1	26.5	22.3
December 20	28.9	19.9	24.6	27.8	21.7
December 27	28.5	21.1	24.3	26.8	22.3
1913.					
January 3	28.0	22.1	24.1	26.6	23.0
January 10	28.1	21.9	24.6	27.2	23.0
January 17	29.0	21.4	24.6	27.4	22.2
January 24	29.0	21.0	24.3	28.1	22.1
January 31	26.8	20.6	23.2	25.8	21.7
February 7	28.9	20.9	23.4	27.0	22.1
February 14	29.4	21.2	24.6	28.3	22.0
February 21	29.3	20.0	24.1	28.6	22.0
February 28	30.1	21.7	24.6	28.4	22.5
March 7	30.0	22.1	25.7	28.0	22.5
March 14	31.7	21.3	26.1	30.9	22.9
March 21	31.5	22.7	26.3	30.9	23.4
March 28	31.1	20.8	26.1	30.3	21.9
April 4	30.7	20.1	25.6	29.0	22.1
April 11	30.4	19.6	25.0	28.9	21.0
April 18	29.7	21.0	26.1	28.7	21.9
April 25	31.5	22.0	26.2	30.3	22.6
May 2	31.4	22.3	26.4	30.7	22.7
May 9	28.5	22.4	26.7	27.0	23.3
May 16	32.2	22.5	26.5	31.1	22.9

TABLE LX.—*Temperature for weekly periods under second-growth trees near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1913.					
May 23	33.0	23.0	26.4	31.0	23.7
May 30	31.1	24.0	27.3	31.1	24.0
June 6	33.0	24.0	28.0	31.6	24.4
June 13	32.2	22.9	27.0	31.6	23.5
June 20	33.9	22.0	27.1	31.7	23.2
June 27	31.1	22.5	26.0	30.8	22.9
July 4	32.0	24.0	26.7	30.2	24.6
July 11	31.9	23.5	26.4	30.3	24.4
July 18	30.9	23.5	26.0	28.1	24.4
July 25	29.0	23.5	26.2	27.8	24.4
August 1	30.0	24.0	26.0	28.4	24.7
August 8	30.2	22.0	25.0	28.4	23.0
August 15	31.0	22.1	26.4	29.7	23.9
August 22	30.1	22.8	25.0	28.8	23.4
August 29	29.5	22.8	25.5	28.6	23.4
September 5	29.5	22.3	26.0	28.7	23.5
September 12	31.0	22.0	26.0	29.2	23.3
September 19	30.0	22.9	26.2	29.5	24.1
September 26	30.0	22.7	23.2	29.3	23.4
October 3	32.0	23.0	27.0	30.3	24.4
October 10	29.9	22.5	26.0	28.7	23.4
October 17	29.1	22.5	24.6	26.6	23.1
October 24	27.5	22.8	25.2	27.0	23.4
October 31	29.0	21.0	26.4	27.1	22.9
November 7	29.0	23.1	25.0	26.9	23.9
November 14	28.0	22.0	25.3	26.2	23.8
November 21	27.5	22.4	25.0	26.1	23.2
November 28	27.5	22.5	24.6	25.8	23.4
December 5	27.5	22.1	24.6	26.8	23.1
December 12	27.6	22.7	24.6	26.5	23.2
December 19	27.0	22.6	24.6	25.8	23.3
December 26	28.5	22.4	25.0	26.4	23.0
1914.					
January 2	26.9	22.0	23.6	25.2	22.4
January 9	28.0	21.0	23.6	25.6	21.7
January 16	27.3	20.0	24.0	26.0	21.8
January 23	27.0	20.3	24.0	26.4	21.5
January 30	27.5	20.3	23.4	26.7	21.5
February 6	28.3	20.3	24.3	27.1	21.4
February 13	26.7	20.4	23.7	25.6	21.7
February 20	30.0	20.8	25.0	28.4	21.3
February 27	31.5	20.6	25.5	30.1	21.5
March 6	32.6	23.0	27.0	30.0	24.0
March 13	33.5	22.5	28.0	32.2	23.8
March 20	32.9	23.0	27.4	31.6	23.9
March 27	33.0	23.5	28.6	31.9	24.3
April 3	33.3	24.0	28.3	32.6	24.7

TABLE LX.—*Temperature for weekly periods under second-growth trees near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1914.					
April 10	33.4	25.0	28.6	31.5	25.6
April 17	33.0	23.5	28.3	32.5	24.9
April 24	33.8	25.4	29.0	32.1	25.9
May 1	34.1	25.5	29.5	33.4	25.9
May 8	34.6	25.5	28.3	33.6	26.0
May 15	34.0	25.0	28.6	32.3	25.4
May 22	34.0	23.4	29.0	32.5	25.0
May 29	34.0	25.3	29.5	33.7	25.8
June 5	33.6	25.4	26.2	31.2	25.7
June 12	32.5	24.0	28.3	32.1	25.5
June 19	32.7	24.5	27.4	30.5	25.6
June 26	29.5	23.7	26.0	28.7	24.1
July 3	30.4	23.5	27.2	29.8	24.7
July 10	31.9	24.3	28.0	29.2	25.6
July 17	32.0	24.0	28.3	31.1	26.8
July 24	30.1	24.0	26.0	29.0	24.7
July 31	31.4	23.1	26.7	29.3	24.0
August 7	31.0	23.9	26.3	30.1	24.3
August 14	29.7	22.8	26.5	28.5	24.4
August 21	31.0	23.4	28.9	30.1	24.9
August 28	30.9	24.4	28.1	29.8	26.7
September 4	30.8	24.0	26.4	28.2	25.5
September 11	30.0	23.5	26.7	28.2	25.0
September 18	30.9	22.8	26.2	29.3	23.7
September 25	31.0	22.3	26.0	29.3	23.3
October 2	31.0	21.8	26.0	28.8	23.6
October 9	31.0	24.0	26.7	29.7	24.9
October 16	30.0	24.0	26.0	29.2	24.5
October 23	29.9	23.4	25.3	28.2	24.0
October 30	30.0	24.0	26.4	29.4	24.5
November 6	30.0	24.0	27.1	29.4	24.6
November 13	31.0	24.0	27.0	29.6	24.8
November 20	30.3	24.0	26.4	29.4	24.6
November 27	31.1	23.0	26.8	29.8	24.6
December 4	29.9	23.6	25.2	27.8	24.1
December 11	29.3	22.9	25.0	28.1	24.1
December 18	29.7	23.3	25.3	28.2	24.1
December 25	29.3	23.0	25.8	28.0	24.1
1915.					
January 1	28.9	22.3	25.0	28.3	22.7

TABLE LXI.—*Temperature for periods of four weeks from October, 1911, to January, 1915, under second-growth trees near the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
January 31	29.0	19.4	24.1	26.9	21.6
February 28	31.5	19.8	24.7	28.0	21.8
March 28	33.7	20.7	26.8	30.7	23.0
April 25	33.8	19.6	27.2	31.0	23.5
May 23	34.6	22.3	27.7	31.8	24.2
June 20	34.0	22.0	27.3	31.6	24.1
July 18	32.7	22.5	26.5	30.0	24.3
August 15	31.4	20.2	25.7	28.3	23.4
September 12	31.0	20.3	26.3	28.6	23.9
October 10	32.3	21.8	26.2	29.7	23.8
November 7	31.6	19.9	25.8	28.3	23.5
December 5	31.1	20.0	25.6	28.0	23.4
January 2	31.9	19.9	24.7	27.4	22.8
Average			26.1	29.2	23.3

The temperatures as recorded in these tables are very similar to those for most places in the lowlands in the Philippines. Table LXI shows a mean annual temperature for the period from October, 1911, to January, 1915, of 26.1°. The mean temperature for Manila * from 1885 to 1907 was 26.8°. The absolute maximum recorded for Manila during the same years was 37.7°, and the minimum, 15°. As might be expected from the longer time covered by the Manila records, the extremes are greater than those recorded for Los Baños; the maximum in the latter place being 34.6°, and the minimum, 19.4°.

From Table LXI it will be seen that the average variation in the mean temperature is comparatively slight. Thus, the lowest mean temperature for a corresponding four-week period is 24.1°, and the highest, 27.7°, a difference of 3.6°. The highest mean temperature for any week was 29.5°, for the weeks ending May 1 and May 29, 1914; and the lowest was 23.2°, for the weeks ending January 31 and September 26, 1913, respectively. The average daily variation in temperature is also comparatively slight, the average daily maximum for the entire period from October, 1911, to January, 1915, being 29.2°, and the average daily minimum, 23.3°, or an average daily range of 5.9°.

Temperatures were also recorded, in the manner previously described, in the top of a comparatively tall second-growth tree. The position of this instrument was changed several times.

* *Annual Rept. P. I. Weath. Bur.* (1907), 151.

owing to attacks of termites. Similar trees were selected in each case, and these changes in position seem to have had little or no effect on the results. The trees selected were in each case situated at the top of a ridge. In preparing a place for the instrument one of the tallest trees was always chosen. The top of the main stem was then cut off, so that the stem might form a support for the instrument case. The remainder of the tree was then trimmed, so that the instrument was placed in the very top of the canopy.

The thermometer placed in the top of the tree was read weekly until July, 1913, after which daily readings were taken. Summaries of the weekly readings will be presented later in comparison tables. The results of the daily readings are recorded in Table LXII in the form of weekly maxima, weekly minima, and

TABLE LXII.—*Temperature for weekly periods in the top of a second-growth tree near the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give degrees centigrade.]

Week ending—	Maximum.	Minimum.	Average of daily—	
			Maxima.	Minima.
1913.				
July 4	41.0	26.0	39.5	28.3
July 11	38.5	26.0	37.3	26.6
July 18	39.5	21.0	33.1	25.4
July 25	34.5	23.5	31.8	25.6
August 1	36.5	25.0	31.6	26.3
August 8	34.5	24.5	32.8	25.4
August 15	37.5	24.5	35.5	26.6
August 22	39.5	25.5	35.3	26.1
August 29	37.0	25.0	34.4	25.7
September 5	37.5	24.5	33.9	26.0
September 12	38.5	24.5	33.8	26.2
September 19	38.5	25.5	35.4	26.7
September 26	40.5	25.5	37.2	26.1
October 3	41.5	25.5	39.0	26.3
October 10	39.0	25.5	36.9	26.2
October 17	37.5	24.5	32.8	25.7
October 24	40.0	25.5	36.6	25.8
October 31	38.5	24.5	36.1	26.1
November 7	35.5	26.0	33.6	26.4
November 14	35.5	24.0	32.6	25.6
November 21	35.0	24.5	33.4	25.2
November 28	35.0	24.0	31.8	25.1
December 5	37.0	25.0	35.1	25.4
December 12	33.0	24.5	30.7	25.3
December 19	35.5	24.5	31.1	25.6
December 26	34.5	24.5	32.4	25.4
1914.				
January 2	35.0	24.2	31.1	25.1
January 9	37.5	22.5	31.8	23.9
January 16	33.5	21.5	32.1	23.9

TABLE LXII.—*Temperature for weekly periods in the top of a second-growth tree near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Week ending—	Maximum.	Minimum.	Average of daily—	
			Maxima.	Manima.
1914.				
January 23	37.0	23.0	33.8	24.1
January 30	35.0	23.0	32.4	23.2
February 6	35.5	23.5	33.5	24.3
February 13	34.5	23.1	31.9	26.1
February 20	34.5	22.5	31.9	23.2
February 27	36.0	22.5	34.3	23.2
March 6	33.1	24.5	32.5	25.2
March 13	37.0	24.0	35.3	25.3
March 20	36.0	24.5	24.5	25.2
March 27	35.5	25.0	34.9	25.3
April 3	35.5	24.5	34.4	24.9
April 10	37.0	26.0	34.5	26.5
April 17	38.0	24.5	35.1	26.0
April 24	38.9	26.0	35.9	27.0
May 1	39.1	26.5	37.4	27.1
May 8	38.2	26.9	36.8	27.1
May 15	39.0	26.5	37.2	27.4
May 22	40.0	26.2	37.5	26.8
May 29	40.9	25.5	38.9	27.0
June 5	41.0	25.1	33.3	26.1
June 12	40.9	26.2	39.0	27.0
June 19	39.5	26.5	37.4	27.2
June 26	38.0	25.2	35.4	26.3
July 3	38.9	26.0	36.6	26.9
July 10	36.5	25.9	33.6	26.6
July 17	39.5	25.0	36.3	27.7
July 24	46.5	25.0	41.4	25.7
July 31	48.0	24.9	37.6	26.0
August 7	47.6	25.1	44.5	25.5
August 14	44.0	25.0	38.1	25.8
August 21	43.0	23.9	40.1	25.7
August 28	38.5	24.6	35.5	26.8
September 4	39.5	25.0	32.5	25.7
September 11	34.1	24.1	30.8	25.6
September 18	40.0	23.5	36.9	24.9
September 25	44.0	24.8	40.5	25.5
October 2	41.2	24.9	36.3	25.4
October 9	43.5	25.0	38.9	26.0
October 16	41.6	25.0	39.8	25.7
October 23	37.9	25.0	35.8	26.7
October 30	37.2	24.9	35.8	25.4
November 6	39.0	25.0	36.8	25.7
November 13	38.9	25.0	35.8	25.8
November 20	37.8	25.0	36.6	25.9
November 27	39.5	26.0	37.1	26.3
December 4	34.8	25.0	32.4	25.5
December 11	34.0	24.5	33.1	25.5
December 18	35.8	24.8	33.7	25.5
December 25	38.1	23.5	35.3	25.4
1915.				
January 1	36.9	24.0	35.2	25.0

averages of daily maxima and minima. The figures in this table are summarized for corresponding four-week periods for the two years, in the form of maxima, minima, and averages of daily maxima and minima in Table LXIII.

TABLE LXIII.—*Temperature for periods of four weeks from July, 1913, to January, 1915, in the top of a second-growth tree near the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	Maximum.	Minimum.	Average of daily—	
			Maxima.	Minima.
January 30	37.5	21.5	32.5	23.8
February 27	36.0	22.5	32.9	24.2
March 27	37.0	24.0	34.3	25.3
April 24	38.9	24.5	35.0	26.1
May 22	40.0	26.2	37.2	27.1
June 19	41.0	25.1	37.2	26.8
July 17	41.0	21.0	36.1	26.9
August 14	48.0	23.5	36.7	25.9
September 11	43.0	23.9	34.6	26.0
October 9	44.0	23.5	37.7	25.9
November 6	41.6	24.5	36.0	26.0
December 4	39.5	24.0	34.4	25.6
January 1	38.1	23.5	32.8	25.4
Average	40.4	23.7	35.2	25.8

The maximum temperature for the whole period was 48°, and the minimum was 21.0°. The average daily maximum for the entire period was 35.2°; and the average daily minimum, 25.8°. The average daily maximum was 6° higher than under the second-growth trees. The average daily minimum was also higher in the top of the tree than under the second-growth trees. The patch of second-growth trees under which the recording instrument was placed was very open, especially on the side toward the mountain, so that the thermometer was exposed to the cold winds which come down the mountain at night. As cold wind settles at the bottom this may account for the minimum temperatures under the trees being lower than in the top of the tree.

TEMPERATURE IN THE DIPTEROCARP FOREST

The records of temperature in the dipterocarp forest were obtained at two stations; namely, station 2, at an elevation of 300 meters, and station 3, at an elevation of 450 meters. For convenience the temperatures at these two stations will be discussed separately.

At 300 meters' elevation the records of temperature were obtained by means of a Draper recording thermometer in the undergrowth and by maximum and minimum thermometers in the crown of a second-story tree and in the top of a first-story tree. The first-story tree was a dominant *Parashorea malaanonan,* which projected above the main canopy. The extreme top of this tree was removed and a place for the instrument prepared in the manner described for the second-growth tree.

The temperatures in the undergrowth are recorded in Table LXIV, in the form of weekly maxima, weekly minima, means, and average of daily maxima and minima. These figures are summarized in Table LXV.

TABLE LXIV.—*Temperature for weekly periods in undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 300 meters.*

[Numbers give degrees centigrade.]

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1912.					
October 11	26.6	21.7	23.2	25.2	22.2
October 18	25.6	21.7	22.8	24.3	22.4
October 25	24.8	21.1	22.7	24.2	22.2
November 1	26.6	21.1	24.0	25.9	22.8
November 8	26.1	22.2	22.9	24.6	22.4
November 15	25.6	21.1	22.8	24.6	22.1
November 22	25.9	20.8	22.8	24.4	21.8
November 29	25.6	21.1	22.7	24.0	22.0
December 6	25.6	20.8	22.3	24.4	21.6
December 13	24.5	19.4	21.7	22.6	20.6
December 20	24.5	19.2	21.8	23.4	20.4
December 27	23.9	20.0	21.6	22.7	20.7
1913.					
January 3	24.2	20.0	21.7	22.7	21.0
January 10	23.9	20.8	22.2	23.2	21.4
January 17	24.8	20.3	22.0	23.4	20.8
January 24	24.5	20.3	21.9	23.2	20.8
January 31	22.2	18.6	20.5	21.6	19.9
February 7	23.9	18.9	21.6	22.6	20.3
February 14	25.0	19.4	21.8	23.9	20.4
February 21	25.0	19.4	22.1	23.9	20.5
February 28	25.6	19.7	22.2	24.2	21.0
March 7	25.0	19.4	21.9	23.2	21.1
March 14	27.2	20.3	23.5	26.0	21.6
March 21	27.7	21.1	23.4	26.6	21.2
March 28	27.5	19.4	23.3	26.9	20.7
April 4	27.5	20.3	23.3	26.4	21.2
April 11	27.7	19.4	23.7	26.8	20.8
April 18	26.6	21.4	23.8	25.9	22.4
April 25	28.0	21.4	24.4	26.7	22.2
May 2	28.0	21.7	24.5	27.4	23.2

TABLE LXIV.—*Temperature for weekly periods in undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 300 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1913.					
May 9	25.9	21.1	23.2	24.7	22.1
May 16	28.3	20.5	24.3	27.4	21.8
May 23	28.3	21.7	24.4	26.7	22.5
May 30	27.7	21.7	24.5	27.0	22.6
June 6	29.7	22.7	25.3	28.1	23.5
June 13	29.4	21.7	25.6	28.5	22.7
June 20	29.7	21.7	25.1	27.8	22.7
June 27	27.7	20.5	23.9	26.7	21.6
July 4	27.2	21.7	24.0	26.0	22.4
July 11	27.2	22.0	23.9	26.1	22.5
July 18	27.2	21.4	23.3	24.6	22.1
July 25	25.6	21.7	23.1	24.9	22.0
August 1	26.1	21.7	23.2	24.8	22.5
August 8	27.2	21.4	22.7	25.0	22.0
August 15	27.4	21.1	24.4	26.0	22.8
August 22	27.4	21.7	23.7	25.6	22.1
August 29	25.6	20.5	22.7	24.7	21.9
September 5	26.4	21.1	23.3	25.3	22.0
September 12	27.4	21.1	23.8	25.8	21.9
September 19	26.9	20.8	24.0	26.0	22.5
September 26	26.6	21.1	23.3	25.8	22.1
October 3	27.7	21.4	23.8	26.4	22.2
October 10	26.4	21.1	23.3	25.6	21.9
October 17	25.8	21.1	22.9	24.8	21.8
October 24	25.6	20.8	22.7	24.9	21.4
October 31	25.6	19.4	22.5	24.6	21.1
November 7	25.6	21.7	22.7	24.1	22.3
November 14	25.0	19.4	22.6	23.8	21.2
November 21	24.5	20.0	21.7	23.3	20.9
November 28	24.5	19.4	21.5	22.7	20.6
December 5	23.9	20.5	22.2	23.2	20.7
December 12	24.2	20.0	21.5	22.7	20.9
December 19	23.8	20.3	22.0	22.7	21.0
December 26	25.0	20.0	22.0	23.2	21.1
1914.					
January 2	23.3	19.7	21.3	22.3	20.4
January 9	23.3	18.0	20.3	21.6	19.2
January 16	23.3	16.6	20.5	22.0	18.9
January 23	23.0	18.9	21.0	22.5	19.7
January 30	23.9	18.6	20.5	22.6	19.2
February 6	24.2	19.2	21.1	23.3	19.8
February 13	23.6	18.6	21.0	22.3	19.4
February 20	24.2	18.0	21.1	22.8	18.6
February 27	21.4	17.4	21.3	22.4	18.5
March 6	27.7	19.7	22.2	24.8	20.9
March 13	27.5	18.9	23.4	25.8	20.8
March 20	27.1	20.3	22.9	26.0	21.1
March 27	27.7	20.5	22.8	26.4	26.4

TABLE LXIV.—*Temperature for weekly periods in undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 300 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
1914.					
April 3	27.5	20.0	23.4	26.7	21.0
April 10	27.5	22.2	24.1	26.0	22.3
April 17	28.3	20.5	23.9	27.1	22.0
April 24	28.3	22.5	24.6	26.8	22.6
May 1	29.4	22.2	24.8	27.7	22.5
May 8	28.3	22.2	25.2	28.0	22.8
May 15	28.9	22.2	25.4	28.2	23.1
May 22	29.4	22.2	25.2	28.4	22.7
May 29	27.5	21.4	25.2	26.7	22.2
June 5	26.6	18.9	24.1	23.8	21.1
June 12	28.6	22.0	25.1	27.6	22.8
June 19	28.4	22.0	24.7	26.3	22.6
June 26	26.6	20.8	23.5	25.8	22.3
July 3	27.7	21.7	24.1	26.0	22.6
July 10	27.7	21.7	23.5	25.5	22.8
July 17	28.0	21.7	25.6	26.7	24.3
July 24	26.1	20.5	23.5	25.9	21.8
July 31	26.6	19.4	23.9	25.7	21.7
August 7	28.0	21.1	24.2	26.8	21.9
August 14	25.6	21.1	22.9	24.7	22.4
August 21	27.2	21.1	24.1	26.3	22.3
August 28	27.5	20.8	24.7	26.0	23.1
September 4	26.1	21.4	23.5	24.4	22.4
September 11	26.6	20.8	22.7	24.7	22.2
September 18	25.9	19.7	22.4	24.8	20.6
September 25	26.3	20.5	23.3	25.9	21.9
October 2	25.9	20.5	22.9	24.7	21.3
October 16	25.6	20.8	22.7	24.6	21.3
October 23	25.3	20.5	22.7	23.9	21.5
October 30	25.0	21.1	22.8	24.4	21.4
November 6	25.3	20.5	22.9	24.2	21.5
November 13	25.0	21.4	22.8	24.7	22.1
November 20	25.6	21.1	23.3	24.9	22.0
November 27	25.6	21.1	23.5	25.1	22.1
December 4	25.0	21.1	22.4	23.4	21.8
December 11	24.8	20.5	22.7	23.7	21.6
December 18	24.5	20.8	22.4	23.6	21.3
December 25	23.9	20.0	21.8	23.3	20.7
1915.					
January 1	23.9	19.4	21.2	23.1	19.9

TABLE LXV.—*Temperature for periods of four weeks from October, 1912, to January, 1915, in undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 300 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
January 31	24.8	16.6	21.2	22.5	20.0
February 28	25.6	17.4	21.5	23.2	19.8
March 28	27.7	18.9	22.9	25.8	21.8
April 25	28.3	19.4	23.9	26.6	21.9
May 23	29.4	20.5	24.7	27.4	22.6
June 20	29.7	18.9	25.0	27.0	22.6
July 18	28.0	20.5	24.0	25.9	22.6
August 15	28.0	19.4	23.5	25.5	22.2
September 12	27.5	20.5	23.6	25.4	22.2
October 10	27.7	19.7	23.3	25.5	21.8
November 7	26.6	19.4	22.9	24.6	21.9
December 5	25.9	19.4	22.6	24.1	21.6
January 2	25.0	19.2	21.8	23.0	20.8
Average	27.2	19.2	23.1	25.1	21.7

As might be expected, the temperature was lower in the dipterocarp forest at an elevation of 300 meters than in the second-growth forest at the base of the mountain. The mean for the entire period from November, 1912, to January, 1915, was 23.1°, the maximum was 29.7°, and the minimum was 16.6°. The extreme range was not very different from that recorded under the second-growth trees. In the dipterocarp forest the extreme range was 13.3°, and under the second-growth trees it was 15.2°. The average daily maximum in the dipterocarp forest was 25.1°, and the average daily minimum was 21.7°; so that the average daily variation was 3.4°, against 5.9° under the second-growth trees. This difference in range in the two situations would very evidently appear to be connected with the evener conditions found in the dipterocarp forest, which result from the development of a dense canopy that almost excludes the direct sun and very greatly reduces the velocity of the wind. The effect of the canopy in reducing the velocity of the wind under the forest is evident on the most casual observation, for a fairly strong wind may be blowing over the tops of the trees when there is practically no motion in the undergrowth. Were it not for this lessened wind movement, it would be almost or quite impossible to take photographs in the forest; as, in order to get detail in the subdued light, an exposure of several minutes is frequently necessary.

The highest mean temperature recorded for any week was 25.6°, for the week ending June 13, 1913; and the lowest was 20.3°, for the week ending January 9, 1914.

The above discussion of temperature in the dipterocarp forest at an elevation of 300 meters shows that plants in the undergrowth developed under very even temperature conditions.

The maximum and minimum thermometers in the trees were read weekly. In Table LXVI are shown the weekly maxima

TABLE LXVI.—*Temperature for weekly periods in the dipterocarp forest on Mount Maquiling; altitude, 300 meters.*

[Numbers give degrees centigrade.]

Week ending—	In top of tall tree.		In second-story tree.		In undergrowth.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
1912.						
October 25	29.5	20.0			24.8	21.1
November 1	31.5	20.5			26.6	21.1
November 8	31.5	20.5			26.1	22.2
November 15	28.0	19.5	26.5	21.5	25.6	21.1
November 22	32.0	19.0	25.0	20.5	25.9	20.8
November 29	29.7	19.5	25.0	20.5	25.6	21.1
December 6	26.0	19.0	24.0	21.0	25.6	20.8
December 13	27.0	17.5	23.5	19.0	24.5	19.4
December 20	32.0	19.0	24.5	19.0	24.5	19.2
December 27	30.5	21.5	28.0	17.0	23.9	20.0
1913.						
January 3	29.5	19.0	24.0	21.0	24.2	20.0
January 10	28.0	20.0	24.0	20.5	23.9	20.8
January 17	29.5	18.0	24.5	20.5	24.8	20.3
January 24	37.0	21.5	25.0	20.0	24.5	20.3
January 31	29.0	17.0	27.0	18.0	22.2	18.6
February 7	32.5	19.5	29.0	19.0	23.9	18.9
February 14	35.0	19.5	24.0	20.0	25.0	19.4
February 21	28.0	19.0	24.0	20.0	25.0	19.4
February 28	37.0	18.5	30.5	17.5	25.6	19.7
March 7	35.0	22.0	27.0	20.5	25.0	19.4
March 14	39.0	18.0	31.5	20.0	27.2	20.3
March 21	39.0	22.5	26.5	21.5	27.7	21.1
March 28	35.5	18.5	26.5	20.5	27.5	19.4
April 4	32.5	19.0	27.0	20.5	27.5	20.3
April 11	33.0	19.0	27.0	20.5	27.7	19.4
April 18	33.0	20.5	27.0	22.0	26.6	21.4
April 25	32.0	21.0	27.0	22.0	28.0	21.4
May 2	33.0	20.5	27.0	22.5	28.0	21.7
May 9	28.0	20.0	25.5	21.5	25.9	21.1
May 16	34.0	20.5	28.0	21.0	28.3	20.5
May 23	35.5	21.0	28.0	22.0	28.3	21.7
May 30	33.0	20.5	27.5	22.5	27.7	21.7
June 6	36.0	22.0	29.0	24.0	29.7	22.7
June 13	34.5	21.5	29.0	23.0	29.4	21.7

TABLE LXVI.—*Temperature for weekly periods in the dipterocarp forest on Mount Maquiling; altitude, 300 meters*—Continued.

Week ending—	In top of tall tree.		In second-story tree.		In undergrowth.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
1913.						
June 20	36.7	21.3	29.5	21.5	29.7	21.7
June 27	34.0	21.0	27.5	22.0	27.7	20.5
July 4	32.5	20.0	27.5	21.9	27.2	21.7
July 11	33.5	21.0	27.0	22.0	27.2	22.0
July 18	33.5	22.0	26.0	22.0	27.2	21.4
July 25	32.1	21.0	24.0	22.5	25.6	21.7
August 1	30.5	20.5	25.5	21.5	26.1	21.7
August 8	29.5	20.5	25.0	21.0	27.2	21.4
August 15	28.5	19.5	28.0	22.0	27.4	21.1
August 22	32.5	21.0	27.5	21.5	27.4	21.7
August 29	30.5	23.5	25.5	21.5	25.6	20.5
September 5	30.0	20.5	26.5	20.5	26.4	21.1
September 12	30.5	19.5	27.5	21.0	27.4	21.1
September 19	32.5	20.5	27.5	22.0	26.9	20.8
September 26	35.0	20.5	27.5	21.5	26.6	21.1
October 3	36.5	21.0	28.5	22.0	27.7	21.4
October 10	34.5	20.5	26.5	22.0	26.4	21.1
October 17	34.5	19.5	26.5	21.5	25.8	21.1
October 24	32.5	21.5	27.0	20.5	25.6	20.8
October 31	31.5	18.5	26.5	19.5	25.6	19.4
November 7	27.5	20.5	26.0	22.0	25.6	21.7
November 14	28.5	19.5	25.5	19.5	25.0	19.4
November 21	29.0	19.0	25.0	20.0	24.5	20.0
November 28	29.0	19.0	24.5	19.5	24.5	19.4
December 5	31.0	19.0	24.5	20.0	23.9	20.5
December 12	26.5	19.5	24.5	21.0	24.2	20.0
December 19	26.5	19.0	24.5	21.0	23.8	20.3
December 26	29.5	19.5	24.5	21.0	25.0	20.0
1914.						
January 2	31.0	18.5	25.1	20.0	23.3	19.7
January 9	29.5	16.5	24.1	18.0	23.3	18.0
January 16	27.0	15.9	23.5	17.0	23.3	16.6
January 23	29.0	17.5	23.5	19.5	23.0	18.9
January 30	31.5	17.0	24.1	19.5	23.9	18.6
February 6	28.5	18.0	30.0	19.5	24.2	19.2
February 13	30.0	17.5	26.0	19.0	23.6	18.6
February 20	28.5	17.2	25.5	18.5	24.2	18.0
February 27	33.5	17.0	26.0	18.9	21.4	17.4
March 6	28.0	19.5	26.0	21.0	27.7	19.7
March 13	30.5	19.2	28.0	20.5	27.5	18.9
March 20	37.0	20.0	28.0	20.5	27.1	20.3
March 27	34.5	19.5	28.0	21.0	27.7	20.5

TABLE LXVI.—*Temperature for weekly periods in the dipterocarp forest on Mount Maquiling; altitude, 300 meters*—Continued.

Week ending—	In top of tall tree.		In second-story tree.		In undergrowth.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
1914.						
April 3	30.0	18.5	28.0	20.0	27.5	20.0
April 10	32.0	20.5	28.0	22.0	27.5	22.2
April 17	33.0	19.0	28.0	20.5	28.3	20.5
April 24	29.2	21.5	28.5	22.5	28.3	22.5
May 1	33.0	22.1	29.3	22.9	29.4	22.2
May 8	35.5	21.9	29.5	23.1	28.3	22.2
May 15	38.0	23.0	29.5	23.1	28.9	22.2
May 22	32.5	21.5	29.9	23.0	29.4	22.2
May 29	33.2	21.5	30.9	21.9	27.5	21.4
June 5	33.0	19.5	30.2	21.5	26.6	18.9
June 12	38.0	22.0	30.5	22.5	28.6	22.0
June 19	37.5	20.0	29.9	21.6	28.4	22.0
June 26	30.1	21.0	28.0	22.0	26.6	20.8
July 3	35.0	21.0	29.5	21.8	27.7	21.7
July 10	32.5	21.5	28.9	21.9	27.7	21.7
July 17	34.1	19.0	29.5	21.2	28.0	21.7
July 24	33.9	19.9	28.5	21.0	26.1	20.5
July 31	32.0	21.0	28.2	20.5	26.6	19.4
August 7	30.8	20.6	29.5	21.5	28.0	21.1
August 14	36.5	21.9	26.8	21.5	25.6	21.1
August 21	32.5	21.0	28.5	21.0	27.2	21.1
August 28	32.2	21.0	28.0	21.0	27.5	20.8
September 4	30.0	20.0	27.0	21.9	26.1	21.4
September 11	30.5	20.5	25.5	21.5	26.6	20.8
September 18	36.5	19.5	26.5	19.9	25.9	19.7
September 25	40.0	20.0	28.0	21.0	26.3	20.5
October 2	36.0	19.5	27.5	21.0	25.9	20.5
October 9	38.0	20.0	28.0	21.0		
October 16	33.2	21.0	26.9	21.0	25.6	20.8
October 23	32.0	20.8	26.9	20.8	25.3	20.5
October 30	31.4	20.0	27.0	21.0	25.0	21.1
November 6	31.0	20.0	27.2	21.0	25.3	20.5
November 13	31.0	20.0	26.1	21.5	25.0	21.4
November 20	30.5	20.9	26.5	21.9	25.6	21.1
November 27	30.5	21.5	26.8	22.0	25.6	21.1
December 4	31.1	21.0	25.0	21.3	25.0	21.1
December 11	31.8	19.5	25.0	21.0	24.8	20.5
December 18	30.8	20.5	25.0	20.3	24.5	20.8
December 25	33.0	20.0	26.0	20.2	23.9	20.0
1915.						
January 1	30.0	18.5	24.2	19.8	23.9	19.4

and minima in the top of the first-story tree, in the crown of the second-story tree, and in the undergrowth. These results are summarized in Table LXVII and plotted in fig. 6. From Table LXVII it will be seen that the average weekly maximum in

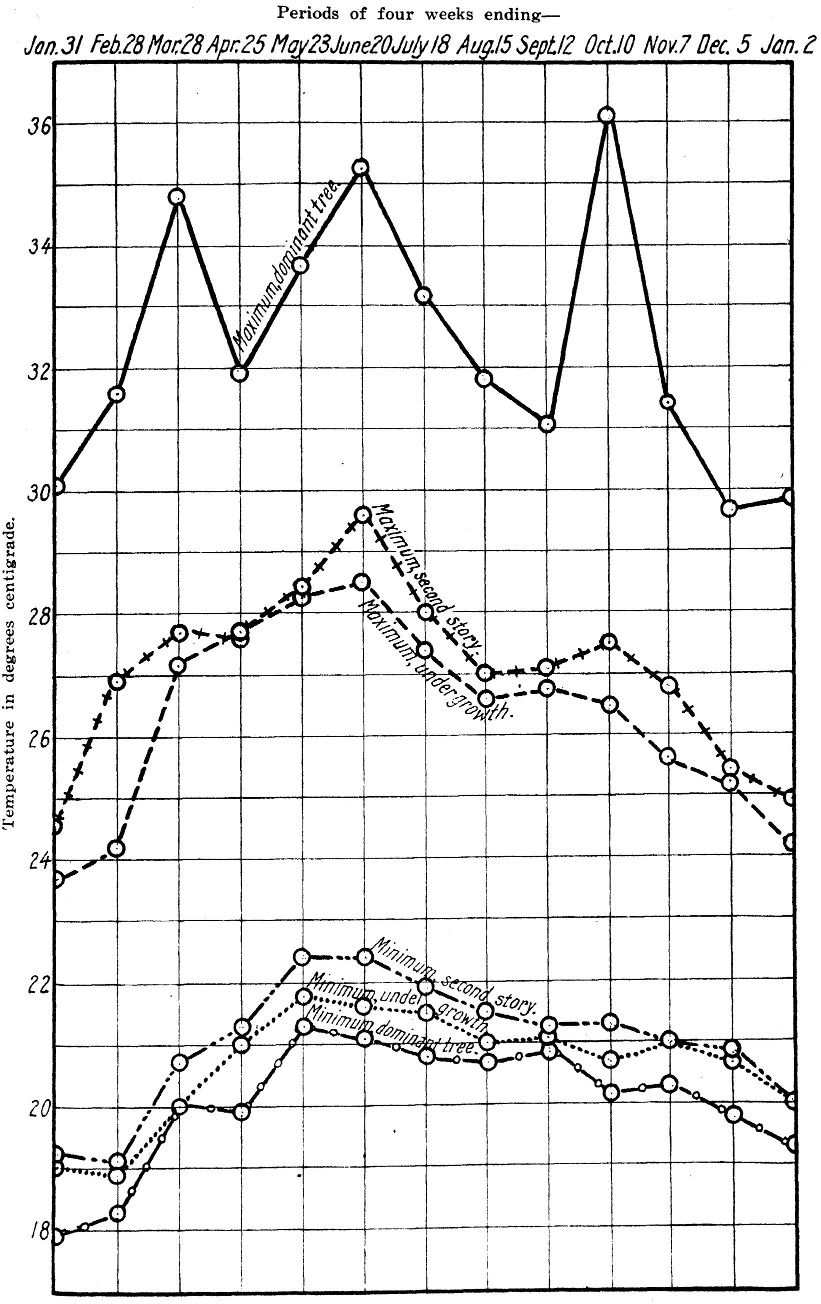

FIG. 6. Average of weekly maximum and minimum temperatures in dipterocarp forest on Mount Maquiling; altitude, 300 meters.

TABLE LXVII.—*Average of weekly maximum and minimum temperatures for periods of four weeks from October, 1912, to January, 1915, in the dipterocarp forest on Mount Maquiling; altitude, 300 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	Undergrowth.		Second story.		Dominant tree.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
January 31	23.7	19.0	24.5	19.2	30.1	17.9
February 28	24.2	18.9	26.9	19.1	31.6	18.3
March 28	27.2	20.0	27.7	20.7	34.8	20.0
April 25	27.7	21.0	27.6	21.3	31.9	19.9
May 23	28.3	21.8	28.4	22.4	33.7	21.3
June 20	28.5	21.6	29.6	22.4	35.3	21.1
July 18	27.4	21.5	28.0	21.9	33.2	20.8
August 15	26.6	21.0	27.0	21.5	31.8	20.7
September 12	26.8	21.1	27.1	21.3	31.1	20.9
October 10	26.5	20.7	27.5	21.3	36.1	20.2
November 7	25.6	21.0	26.8	21.0	31.4	20.3
December 5	25.2	20.7	25.4	20.8	29.7	19.8
January 2	24.2	20.0	24.9	20.0	29.9	19.3
Average	26.3	20.6	27.0	21.0	32.4	20.0

the dominant tree is considerably higher than in the second-story tree. In the dominant tree the average weekly maximum temperature was 32.4°; in the second-story tree, 27°; and in the undergrowth, 26.3°. The average weekly minima in the three cases are very similar, being in the dominant tree, 20°; in the second-story tree, 21°; and in the undergrowth, 20.6°. The lowest average minimum is shown in the dominant tree, and the highest is shown in the second-story tree. Although the differences are comparatively slight, this relation seems to be fairly regular for the different periods, and a similar condition has been found to obtain at an elevation of 450 meters. It would thus appear that this relation is not accidental.

That the lowest minimum should occur in the top of the dominant tree is very readily explained by the fact that this situation is more exposed to radiation and to the cold winds which come down the mountain at night. That the average minimum in the undergrowth should be lower than in the second story is probably due to the fact that cold air sinks while warm air rises.

The reason for the differences in the maximum temperatures is very plain: the dominant trees are fully exposed to the action of the sun and also to the warm winds forced up the mountain from lower elevations during the day; while the second story is

much less exposed to these conditions, and the undergrowth still less.

The absolute maximum for the entire period in the dominant tree was 40°, and the minimum was 15.9°. In the second-story tree the maximum was 31.5°, and the minimum was 17°. In the undergrowth the maximum was 29.7°, and the minimum, 16.6°. This again shows the difference in the range of temperature in the dominant tree, in the second story, and in the undergrowth.

The records of temperature at an elevation of 450 meters were begun July, 1913, and continued to January 1, 1915. Temperature in the undergrowth was taken by means of a Draper recording thermometer in the type of case previously described. Another similar instrument was placed in a case of the same type in the 0.25-hectare clearing shown on the map as plot 2 (Plate XLI). This plot was on the top of a ridge. Standing near the instrument it was possible to look over a wide stretch of the surrounding country, so that this instrument was very freely exposed to the wind. Maximum and minimum thermometers, which were read weekly, were also placed in the crown of a second-story tree and in the top of a dominant tree, as was done at an elevation of 300 meters.

The records for the temperature in the undergrowth are given in Table LXVIII in the form of weekly maxima, weekly minima,

TABLE LXVIII.—*Temperature for weekly periods in undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Numbers give degrees centigrade.]

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1913.					
August 1	28.0	20.8	23.2	24.1	22.9
August 8	25.6	20.8	22.4	23.8	21.9
August 15	26.4	21.7	23.9	25.2	22.6
August 22	26.1	21.4	22.9	24.8	22.3
August 29	25.0	21.1	22.7	24.0	22.0
September 5	25.9	21.1	22.8	24.4	22.0
September 12	26.6	21.4	23.3	24.8	22.2
September 19	26.6	22.7	23.9	25.6	23.1
September 26	26.4	22.2	23.4	25.3	22.5
October 3	27.5	22.0	23.9	26.0	22.8
October 10	25.6	21.4	23.0	25.0	22.4
October 17	25.0	20.0	22.4	23.9	21.5
October 24	25.3	21.4	22.5	24.3	21.8
October 31	25.3	20.5	22.5	24.0	21.6
November 7	25.6	21.4	22.4	23.8	22.2
November 14	24.8	20.3	22.0	23.2	21.3

TABLE LXVIII.—*Temperature for weekly periods in undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 450 meters*—Cont.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1913.					
November 21	23.6	20.5	21.4	22.9	20.9
November 28	24.5	19.7	21.3	22.4	20.5
December 5	23.6	20.5	22.7	22.9	21.1
December 12	23.9	20.0	21.3	22.3	20.7
December 19	23.0	20.0	21.7	22.2	20.7
December 26	23.9	19.7	21.1	22.4	20.6
1914.					
January 2	22.0	18.9	20.5	21.4	19.5
January 9	22.2	17.4	20.0	20.7	18.7
January 16	22.2	17.2	19.4	21.2	19.1
January 23	23.0	19.2	20.7	22.1	19.6
January 30	23.0	18.9	20.2	22.1	19.3
February 6	23.3	19.4	20.7	22.6	19.9
February 13	22.7	18.9	20.5	21.5	19.2
February 20	23.9	18.6	20.2	22.2	19.2
February 27	24.5	18.6	21.3	23.4	19.7
March 6	25.9	19.7	22.2	23.5	20.6
March 13	26.6	19.7	23.3	25.5	21.5
March 20	25.9	21.0	22.7	24.8	21.2
March 27	26.4	20.5	22.9	25.1	21.2
April 3	27.2	20.3	23.4	25.9	21.3
April 10	26.4	21.4	23.3	24.9	22.2
April 17	27.5	21.4	23.5	26.3	22.1
April 24	27.5	22.5	24.4	26.0	23.0
May 1	28.0	22.5	24.7	26.8	22.8
May 8	27.1	22.7	24.8	26.7	23.2
May 15	27.5	22.5	25.5	27.0	23.4
May 22	28.3	23.0	25.2	26.7	23.7
May 29	28.6	22.5	25.2	27.7	23.6
June 5	27.2	20.5	23.4	24.8	22.2
June 12	27.2	23.0	25.2	26.6	23.5
June 19	27.2	21.4	24.1	25.5	22.8
June 26	25.9	20.5	23.3	25.1	22.3
July 3	26.1	22.2	24.1	25.4	22.8
July 10	25.9	21.4	22.7	24.0	22.5
July 17	25.9	21.6	24.5	25.3	23.2
July 24	25.0	21.4	22.9	24.2	22.1
July 31	26.4	21.6	23.5	24.9	22.6
August 7	26.7	22.2	24.5	26.0	22.6
August 14	25.0	21.4	22.7	23.8	22.1
August 21	26.1	21.1	23.9	25.5	22.5
August 28	25.9	20.7	23.5	24.7	22.7
September 4	24.5	20.5	22.7	23.2	21.8
September 11	25.0	20.0	22.2	23.2	21.5
September 18	26.4	20.8	22.4	24.4	21.3
September 25	26.1	21.1	23.9	25.5	22.0
October 2	26.1	20.5	22.9	24.8	21.4
October 9	25.6	21.4	22.7	24.4	22.0
October 16	25.0	21.1	22.4	24.1	21.6

TABLE LXVIII.—*Temperature for weekly periods in undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 450 meters*—Cont.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1914.					
October 23	24.5	20.8	22.4	23.4	21.3
October 30	25.0	20.6	21.9	23.9	21.8
November 6	25.0	21.1	22.4	24.3	21.6
November 13	24.8	21.4	22.4	24.0	21.8
November 20	24.8	21.1	22.7	24.4	22.0
November 27	24.9	21.4	22.4	24.3	22.0
December 4	23.9	20.5	21.7	22.7	21.1
December 11	*23.6	20.5	22.2	22.8	21.0
December 18	23.6	20.5	21.7	22.7	21.1
December 25	23.6	20.5	21.8	22.9	21.1
1915.					
January 1	23.6	20.0	21.3	22.9	20.9

means, and averages of daily maxima and minima. These figures are summarized in Table LXIX. The temperatures are very similar to those at an elevation of 300 meters. The mean was, however, 0.3° lower, while the average daily range was 2.6°, as compared with 3.4° at 300 meters' elevation.

TABLE LXIX.—*Temperature for periods of four weeks from August, 1913, to January, 1915, in undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
January 30	23.0	17.2	20.1	21.5	19.2
February 27	24.5	18.6	20.7	22.4	19.5
March 27	26.6	19.7	22.8	24.7	21.1
April 24	27.5	20.3	23.7	25.8	22.2
May 22	28.3	22.5	25.1	26.8	23.3
June 19	28.6	20.5	24.5	26.2	23.0
July 17	26.1	20.5	23.7	25.0	22.7
August 14	28.0	20.8	23.3	24.6	22.5
September 11	26.6	20.0	23.0	24.4	22.1
October 9	27.5	20.5	23.3	25.2	22.2
November 6	25.6	20.0	22.4	24.0	21.7
December 4	24.9	19.7	22.1	23.4	21.4
January 1	23.9	18.9	21.5	22.5	20.7
Average	26.2	19.9	22.8	24.3	21.7

The temperature in the clearing is given in Table LXX in the form of weekly maxima, weekly minima, means, and average

TABLE LXX.—*Shade temperature in the open on Mount Maquiling; altitude, 450 meters.*

[Numbers give degrees centigrade.]

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1914.					
April 24	33.8	22.8	25.5	28.7	23.0
May 1	33.3	21.2	26.2	31.4	22.9
May 8	30.3	22.8	25.5	29.5	23.1
May 15	31.4	22.0	25.6	30.1	23.1
May 22	32.8	22.8	26.1	30.6	23.4
May 29	33.4	22.3	23.8	27.0	22.6
June 5	31.4	21.0	24.2	27.4	22.3
June 12	32.3	22.8	26.3	30.6	23.4
June 19	31.7	21.1	24.7	28.5	22.7
June 26	30.5	22.0	24.8	28.8	22.7
July 3	30.8	21.7	25.3	29.2	22.7
July 10	30.5	21.7	23.7	27.3	22.3
July 17	31.7	21.1	25.4	29.0	22.8
July 24	29.2	21.1	24.3	28.0	22.1
July 31	32.8	21.2	24.6	29.0	22.3
August 7	32.3	21.7	25.8	30.8	22.3
August 14	28.2	21.7	23.3	25.2	22.2
August 21	30.5	20.6	24.7	28.3	22.3
August 28	28.2	20.1	24.2	26.4	22.6
September 4	26.7	21.2	23.1	24.3	22.2
September 11	26.4	20.5	22.4	24.0	21.7
September 18	32.3	20.5	23.2	26.8	21.1
September 25	32.3	20.8	24.7	29.4	21.7
October 2	30.8	20.5	23.9	28.2	21.4
October 9	30.1	21.7	24.2	28.0	22.1
October 16	29.0	21.1	23.6	27.6	21.5
October 23	30.8	20.5	23.1	26.9	21.3
October 30	31.1	20.5	23.1	27.5	20.9
November 6	29.5	20.0	23.8	28.2	21.1
November 13	30.0	20.6	23.7	28.2	21.5
November 20	29.0	21.1	24.0	28.1	21.5
November 27	30.0	20.5	24.1	27.6	21.6
December 4	27.5	20.8	22.3	24.5	21.5
December 11	27.2	20.0	22.4	25.2	21.1
December 18	29.0	20.2	22.4	25.9	21.0
December 25	30.8	20.5	24.8	28.5	21.7
1915.					
January 1	27.2	19.5	22.0	25.7	20.0

daily maxima and minima, and the results are summarized in Table LXXI. The temperatures in the open are slightly higher than those in the forest.

The figures in Table LXXI cover only the period from April 24, 1914, to January 1, 1915. The mean temperature for this

TABLE LXXI.—*Shade temperature in the open on Mount Maquiling; altitude, 450 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
1914.					
May 22	33.3	21.2	25.9	30.4	23.1
June 19	33.4	21.0	24.8	28.4	22.8
July 17	31.7	21.1	24.8	28.6	22.6
August 14	32.8	21.1	24.5	28.3	22.2
September 11	30.5	20.1	23.6	25.8	22.2
October 9	32.3	20.5	24.0	28.1	21.6
November 6	31.1	20.0	23.4	27.6	21.2
December 4	30.0	20.5	23.5	27.1	21.5
1915.					
January 1	30.8	19.5	22.9	26.3	21.0
Average			24.2	27.8	22.0

period was 24.2°; whereas for the same period it was 23.2° in the undergrowth, or 1° less than in the open. The average daily maximum was 27.8° in the open and 24.7° in the forest, or 3.1° less in the forest than in the open. The average daily minimum for the same period was 22° in the open and 22.2° in the forest. The higher average maximum in the open, like the higher average maximum in the tops of the trees, is connected with the more open exposure, while the lower average minimum in the open is apparently due to the same cause.

These figures would seem to show very clearly that the forest canopy has an equalizing influence on the temperature under it, as here the average maximum is lower than in the open while the average minimum is higher. The greatest effect of the forest canopy, however, would seem to be due to its influence in reducing the maximum.

The difference between the average maximum under the forest and that in the open, as shown by the above figures for shade temperatures, is of course much less than the actual difference to which plants under the forest and in the open are exposed, as in the latter case the effect of sunlight is important.

In Table LXXII are shown the weekly maximum and minimum temperatures in the top of a dominant *Parashorea*, in the crown of a second-story tree, in the undergrowth, and in the clearing. These results are averaged for corresponding four-week periods in Table LXXIII and plotted in fig. 7. From Table LXXIII it will be seen that the average weekly temperatures in the top

TABLE LXXII.—*Temperature for weekly periods in the dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Numbers give degrees centigrade.]

Week ending—	In clearing, about 75 cm. above the ground.		In dipterocarp forest.					
			In top of tall tree.		In second-story tree.		In undergrowth.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
1913.								
August 15	-------	-------	29.4	18.9	31.7	22.0	26.4	21.7
August 22	-------	-------	30.6	19.4	27.7	22.5	26.1	21.4
August 29	-------	-------	30.0	18.3	27.7	22.5	25.0	21.1
September 5	-------	-------	29.4	18.3	26.6	20.3	25.9	21.1
September 12	-------	-------	31.1	18.9	26.6	20.9	26.6	21.4
September 19	-------	-------	30.6	20.5	27.2	23.1	26.6	22.7
September 26	-------	-------	32.2	20.5	27.2	22.5	26.4	22.2
October 3	-------	-------	35.6	20.5	27.7	22.0	27.5	22.0
October 10	-------	-------	33.3	20.5	26.6	22.5	25.6	21.4
October 17	-------	-------	33.9	18.3	26.6	20.3	25.0	20.0
October 24	-------	-------	34.5	18.9	26.6	20.3	25.3	21.4
October 31	-------	-------	32.7	18.3	26.1	20.3	25.3	20.5
November 7	-------	-------	29.4	20.0	25.6	22.0	25.6	21.4
November 14	-------	-------	28.9	17.7	25.0	19.1	24.8	20.3
November 21	-------	-------	30.0	18.9	24.5	20.3	23.6	20.5
November 28	-------	-------	27.7	17.7	24.5	19.1	24.5	19.7
December 5	-------	-------	30.6	18.9	25.0	20.9	23.6	20.5
December 12	-------	-------	26.6	18.9	24.5	20.3	23.9	20.0
December 19	-------	-------	28.3	18.3	24.5	20.3	23.0	20.0
December 26	-------	-------	29.4	18.3	25.6	20.3	23.9	19.7
1914.								
January 2	-------	-------	31.2	17.7	28.3	19.1	22.0	18.9
January 9	-------	-------	28.3	16.0	25.0	17.5	22.2	17.4
January 16	-------	-------	26.1	16.0	23.3	17.0	22.2	17.2
January 23	-------	-------	28.3	18.3	23.9	19.1	23.0	19.2
January 30	-------	-------	27.7	18.3	23.3	19.1	23.0	18.9
February 6	-------	-------	30.0	18.9	25.0	19.7	23.3	19.4
February 13	-------	-------	29.4	18.3	24.5	19.1	22.7	18.9
February 20	-------	-------	29.4	17.7	24.5	18.6	23.9	18.6
February 27	-------	-------	32.7	17.7	26.6	18.6	24.5	18.6
March 6	-------	-------	28.9	18.9	26.6	20.3	25.9	19.7
March 13	-------	-------	33.9	19.4	28.9	19.7	26.6	19.7
March 20	-------	-------	30.6	18.9	28.3	20.3	25.9	21.0
March 27	-------	-------	30.6	20.0	27.2	20.3	26.4	20.5
April 3	-------	-------	32.2	18.3	27.7	20.3	27.2	20.3
April 10	-------	-------	31.2	20.0	27.7	20.9	26.4	21.4
April 17	-------	-------	31.7	20.5	27.7	20.9	27.5	21.4
April 24	33.8	22.8	31.7	21.7	27.7	22.5	27.5	22.5
May 1	33.3	21.2	33.9	20.5	28.3	22.5	28.0	22.5
May 8	30.3	22.8	30.6	21.7	28.3	23.1	27.1	22.7
May 15	31.4	22.0	31.7	22.2	28.3	23.1	27.5	22.5
May 22	32.8	22.8	32.2	22.2	29.4	23.1	28.3	23.0
May 29	33.4	22.3	32.7	22.2	29.4	23.1	28.6	22.5
June 5	31.4	21.0	32.7	20.0	28.9	20.9	27.2	20.5

TABLE LXXII.—*Temperature for weekly periods in the dipterocarp forest on Mount Maquiling; altitude, 450 meters*—Continued.

Week ending—	In clearing, about 75 cm. above the ground.		In dipterocarp forest.					
			In top of tall tree.		In second-story tree.		In undergrowth.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
1914.								
June 12	32.3	22.8	37.8	22.7	28.3	23.7	27.2	23.0
June 19	31.7	21.1	31.2	20.0	28.3	21.4	27.2	21.4
June 26	30.5	22.0	29.4	20.5	27.2	22.0	25.9	20.5
July 3	30.8	21.7	31.2	21.7	27.2	23.1	26.1	22.2
July 10	30.5	21.7	31.2	18.9	27.2	22.0	25.9	21.4
July 17	31.7	21.1	32.7	20.5	27.2	21.4	25.9	21.6
July 24	29.2	21.1	32.2	20.0	31.2	21.4	25.0	21.4
July 31	32.8	21.2	30.6	20.0	27.2	21.4	26.4	21.6
August 7	32.3	21.7	32.7	21.1	28.3	22.5	26.7	22.2
August 14	28.2	21.7	35.6	20.5	26.1	22.0	25.0	21.4
August 21	30.5	20.6	32.2	20.0	27.7	20.9	26.1	21.1
August 28	28.2	20.1	28.9	18.9	26.6	19.7	25.9	20.7
September 4	26.7	21.2	31.7	18.3	25.6	20.9	24.5	20.5
September 11	26.4	20.5	26.1	18.5	25.6	21.4	25.0	20.0
September 18	32.3	20.5	35.0	20.0	27.2	21.4	26.4	20.8
September 25	32.3	20.8	31.7	19.4	27.7	20.9	26.1	21.1
October 2	30.8	20.5	31.7	20.5	27.2	20.9	26.1	20.5
October 9	30.1	21.7	33.3	20.5	28.3	21.4	25.6	21.4
October 16	29.0	21.1	31.7	21.1	28.9	20.9	25.0	21.1
October 23	30.8	20.5	30.6	19.4	25.6	20.9	24.5	20.8
October 30	31.1	20.5	31.7	19.4	26.6	20.9	25.0	20.6
November 6	29.5	20.0	33.9	20.0	26.6	20.9	25.0	21.1
November 13	30.0	20.6	33.9	18.9	26.1	20.3	24.8	21.4
November 20	29.0	21.1	32.2	20.5	26.1	21.4	24.8	21.1
November 27	30.0	20.5	30.0	20.5	27.7	22.0	24.9	21.4
December 4	27.5	20.8	32.5	19.4	25.6	20.9	23.9	20.5
December 11	27.2	20.0	32.5	19.4	25.0	20.3	23.6	20.5
December 18	29.0	20.2	31.7	18.3	25.0	20.9	23.6	20.5
December 25	30.8	20.5	32.2	20.0	27.2	20.9	23.6	20.5
1915.								
January 1	27.2	19.5	30.0	19.4	24.5	19.7	23.6	20.0

of the dominant tree are slightly higher than those in the clearing. As previously mentioned, it is possible that the temperatures as recorded in the top of the dominant tree may be slightly too high, on account of radiation. It is, however, not improbable that the temperatures in the tops of the tall trees are higher than in the clearing, as the former situation is perhaps more freely exposed to the influence of the hot winds which come up from lower elevations.

As was the case at an elevation of 300 meters, the average maximum temperatures in the second-story tree and under-

growth are considerably lower than in the top of the dominant tree. In the undergrowth the average maximum temperatures are again lower than in the second story. The minimum temperatures in the three situations are very similar, just as was the case at an elevation of 300 meters. Here again the lowest average minimum is in the top of the dominant tree, and the highest is in the second-story tree.

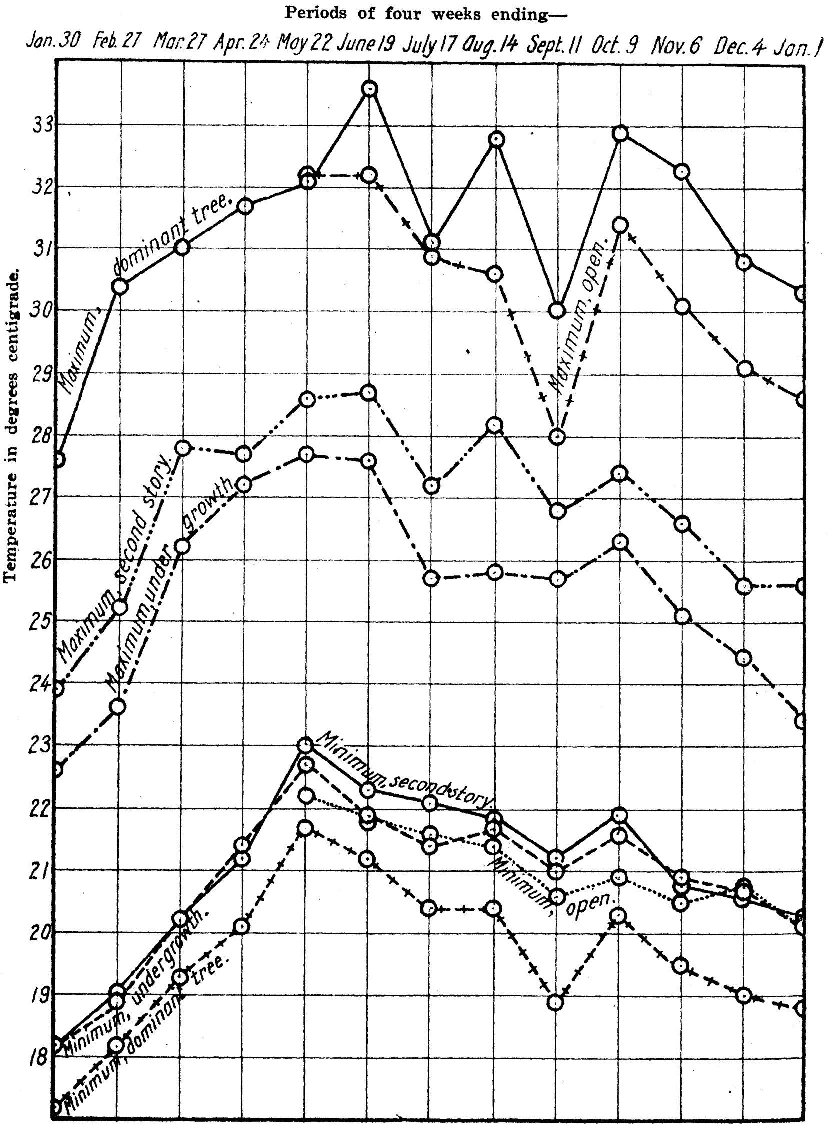

FIG. 7. Average weekly maximum and minimum temperatures in dipterocarp forest on Mount Maquiling; altitude, 450 meters.

TABLE LXXIII.—*Average weekly maximum and minimum temperatures, for periods of four weeks from August, 1913, to January, 1915, in the dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	In clearing, about 75 cm. above the ground.		In dipterocarp forest.					
			In top of tall tree.		In second-story tree.		In undergrowth.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
January 30			27.6	17.2	23.9	18.2	22.6	18.2
February 27			30.4	18.2	25.2	19.0	23.6	18.9
March 27			31.0	19.3	27.8	20.2	26.2	20.2
April 24			31.7	20.1	27.7	21.2	27.2	21.4
May 22	32.2	22.2	32.1	21.7	28.6	23.0	27.7	22.7
June 19	32.2	21.8	33.6	21.2	28.7	22.3	27.6	21.9
July 17	30.9	21.6	31.1	20.4	27.2	22.1	25.7	21.4
August 14	30.6	21.4	32.8	20.4	28.2	21.8	25.8	21.7
September 11	28.0	20.6	30.0	18.8	26.8	21.2	25.7	21.0
October 9	31.4	20.9	32.9	20.3	27.4	21.9	26.3	21.6
November 6	30.1	20.5	32.3	19.5	26.6	20.8	25.1	20.9
December 4	29.1	20.8	30.8	19.0	25.6	20.6	24.4	20.7
January 1	28.6	20.1	30.3	18.8	25.6	20.3	23.4	20.1
Average	30.3	21.1	31.3	19.6	26.9	21.0	25.5	20.8

TEMPERATURES IN THE MIDMOUNTAIN FOREST

The temperature in the undergrowth in the midmountain forest was recorded by means of a Draper recording thermometer.

This was placed in the type of case previously described. The case was located at the side of a broad ridge at an elevation of 740 meters. This station is designated on the map (Plate XLI) as station 4. Maximum and minimum thermometers were also placed in the top of a dominant tree in the immediate neighborhood and read weekly.

In Table LXXIV are recorded the weekly maxima, weekly minima, means, and averages of daily maxima and minima in the undergrowth, and these results are summarized for corresponding four-week periods in Table LXXV. The mean temperature for the entire period was 21.4°, which is 1.7° lower than the mean in the dipterocarp forest at an elevation of 300 meters and 4.7° lower than that under the second-growth trees at an elevation of 80 meters. The maximum temperature for the whole period was 27.5°, as compared with a maximum

TABLE LXXIV.—*Temperature for weekly periods in undergrowth in the mid-mountain forest on Mount Maquiling; altitude, 740 meters.*

[Numbers give degrees centigrade.]

Week ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
1912.					
November 8	22.7	19.4	20.4	21.7	20.0
November 15	21.7	18.9	20.1	21.4	20.0
November 22	23.9	15.5	20.6	22.2	19.6
November 29	22.7	18.9	20.4	21.9	19.4
December 6	23.3	18.9	21.0	22.2	20.0
December 13	21.1	17.1	19.4	20.3	18.7
December 20	23.3	18.0	19.9	21.6	19.2
December 27	22.2	16.3	19.9	21.0	18.5
1913.					
January 3	21.7	18.9	20.3	21.1	19.7
January 10	22.5	18.3	20.1	21.3	19.4
January 17	22.7	18.9	20.5	21.5	19.4
January 24	22.2	18.0	20.2	21.8	19.2
January 31	20.0	16.3	17.9	19.3	17.5
February 7	22.7	16.6	18.3	20.0	17.8
February 14	22.2	16.9	19.3	20.5	17.9
February 21	21.7	17.7	19.2	20.9	18.4
February 28	22.5	17.1	19.8	21.5	18.5
March 7	22.5	18.3	19.8	21.1	18.7
March 14	24.5	18.0	21.5	23.3	19.8
March 21	25.0	19.4	20.9	23.3	19.6
March 28	24.5	18.3	21.6	24.0	19.7
April 4	24.2	18.3	21.0	23.4	19.3
April 11	25.0	18.3	21.6	23.8	19.9
April 18	23.9	20.0	21.8	23.2	20.5
April 25	24.5	19.4	21.8	23.6	20.3
May 2	24.5	20.0	21.9	23.5	20.3
May 9	23.3	20.0	20.9	22.2	20.3
May 16	27.2	21.4	23.2	25.4	21.7
May 23	26.4	20.5	22.4	24.8	21.4
May 30	25.0	20.8	22.5	24.6	21.3
June 6	26.6	21.1	22.8	25.1	21.9
June 13	26.6	21.1	23.2	25.8	21.8
June 20	26.9	21.4	23.1	25.3	21.8
June 27	26.4	21.1	22.6	25.2	21.6
July 4	25.3	21.1	22.5	24.4	21.7
July 11	25.6	20.8	22.1	24.4	21.6
July 18	24.5	19.4	21.7	22.7	20.7
July 25	22.5	19.4	20.6	21.7	20.3
August 1	23.3	20.0	21.1	22.1	20.5
August 8	22.7	20.0	21.2	22.1	20.3
August 15	24.5	20.0	21.7	23.6	20.9
August 22	24.5	20.0	21.8	23.1	20.8
August 29	25.0	19.4	21.1	23.0	20.5
September 5	24.5	19.7	21.2	22.7	20.5
September 12	25.0	20.0	22.1	23.2	21.[illegible]
September 19	25.9	20.5	22.6	24.1	21.6
September 26	25.3	21.1	22.6	24.2	21.5

TABLE LXXIV.—*Temperature for weekly periods in undergrowth in the mid-mountain forest on Mount Maquiling; altitude, 740 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1913.					
October 3	25.6	20.3	22.3	24.8	21.2
October 10	24.5	19.4	21.7	23.8	21.0
October 17	23.3	19.2	21.2	22.5	20.5
October 24	24.2	19.7	21.1	23.1	20.3
October 31	23.6	18.9	20.2	22.3	20.1
November 7	23.9	20.0	21.5	22.5	20.5
November 14	22.5	18.0	20.5	21.8	20.1
November 21	22.7	19.4	20.4	21.7	20.0
November 28	22.5	17.7	19.5	20.8	19.1
December 5	22.2	18.6	20.1	21.7	19.6
December 12	22.5	18.9	20.2	20.9	19.5
December 19	22.0	19.2	21.0	21.2	19.9
December 26	22.7	18.6	20.4	21.6	19.5
1914.					
January 2	22.5	17.7	19.3	20.5	18.7
January 9	22.2	15.5	18.3	19.9	17.6
January 16	20.8	15.5	18.7	20.1	17.6
January 23	21.4	18.0	19.2	20.9	18.4
January 30	21.4	17.1	18.8	20.3	17.6
February 6	22.2	17.7	19.4	21.2	18.5
February 13	21.7	16.9	19.1	20.2	17.7
February 20	22.2	17.1	19.1	20.9	17.6
February 27	22.5	17.4	20.0	22.2	18.5
March 6	23.9	18.3	21.2	22.1	19.3
March 13	25.9	18.6	22.2	24.4	20.2
March 20	24.8	19.7	21.2	23.3	20.0
March 27	24.8	19.4	21.2	23.4	20.1
April 3	25.3	18.6	21.9	24.5	19.9
April 10	25.3	20.5	21.7	23.4	21.0
April 17	25.6	19.2	22.7	24.7	20.7
April 24	25.6	21.1	22.6	24.6	21.6
May 1	26.4	20.8	23.3	25.8	21.8
May 8	25.9	21.4	23.4	25.4	21.9
May 15	26.6	21.4	23.8	26.0	22.3
May 22	26.6	22.2	25.0	26.0	22.5
May 29	27.5	21.4	24.1	26.7	22.1
June 5	26.6	18.9	22.3	23.8	21.1
June 12	26.6	22.2	23.9	26.0	22.5
June 19	26.9	20.3	22.7	24.9	21.8
June 26	25.6	18.3	22.4	24.6	21.2
July 3	26.6	21.1	22.7	25.0	21.9
July 10	25.3	21.1	22.2	23.1	21.8
July 17	24.2	21.1	22.3	23.8	21.8
July 24	25.0	20.5	22.4	24.1	21.3
July 31	25.6	20.5	22.8	24.1	21.7
August 7	27.2	21.1	23.3	26.0	21.6
August 14	24.6	20.5	21.8	23.0	21.3
August 21	25.9	20.8	22.8	24.6	21.6

TABLE LXXIV.—*Temperature for weekly periods in undergrowth in the mid-mountain forest on Mount Maquiling; altitude, 740 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
1914.					
August 28	23.9	19.7	21.9	23.0	21.2
September 4	23.0	20.0	21.7	22.4	21.1
September 11	23.3	19.7	21.8	22.3	21.2
September 18	26.6	20.0	22.2	23.8	20.8
September 25	25.3	20.5	22.7	24.7	21.6
October 2	26.1	20.5	22.4	24.2	21.4
October 9	25.0	20.5	22.2	23.8	21.2
October 16	24.2	18.9	21.1	22.8	20.2
October 23	23.0	19.4	21.0	22.1	20.2
October 30	23.3	19.7	21.3	22.3	20.1
November 6	23.9	18.3	21.7	22.5	19.9
November 13	23.8	19.4	21.4	22.5	20.5
November 20	23.6	20.0	21.8	22.8	20.9
November 27	23.9	20.5	22.2	23.2	21.2
December 4	23.7	18.9	19.6	22.0	20.6
December 11	22.5	18.9	19.6	21.7	20.1
December 18	22.5	19.4	19.4	21.8	20.0
December 25	23.6	19.4	19.5	22.2	20.2

TABLE LXXV.—*Temperature for periods of four weeks from November, 1912, to January, 1915, in undergrowth in the midmountain forest on Mount Maquiling; altitude, 740 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
January 31	22.7	15.5	19.3	20.7	18.4
February 28	22.7	16.6	19.3	20.9	18.2
March 28	25.9	18.0	21.3	23.1	19.7
April 25	25.6	18.3	21.9	23.9	20.4
May 23	27.2	20.0	23.0	24.9	21.5
June 20	27.5	18.9	23.1	25.3	21.8
July 18	26.6	18.3	22.3	24.2	21.6
August 15	27.2	19.4	21.9	23.4	21.0
September 12	25.9	19.4	21.9	23.1	21.0
October 10	26.6	19.4	22.4	24.2	21.3
November 7	24.2	18.3	21.2	22.5	20.3
December 5	23.9	15.5	20.6	22.0	20.1
January 2	23.6	16.3	19.9	21.3	19.5
Average	25.4	18.0	21.4	23.0	20.4

of 29.7° in the dipterocarp forest at an elevation of 300 meters and 34.6° under the second-growth trees at the base of the mountain. The minimum temperature was 15.5°, as compared with 16.6° at an elevation of 300 meters and 19.4° at an altitude of 80 meters. The total range for the entire period was 12°, as compared with 13.1° at an elevation of 300 meters and 15.2° at the base of the mountain. The average daily maximum for the entire period was 23°, and the average daily minimum, 20.4°, the average daily range being 2.6°. This is even less than the small range at an altitude of 300 meters, which was 3.4°.

TABLE LXXVI.—*Temperature for weekly periods in the top of a dominant tree in the midmountain forest on Mount Maquiling; altitude, 740 meters.*

[Numbers give degrees centigrade.]

Week ending—	Maximum.	Minimum.	Week ending—	Maximum.	Minimum.
1912.			1913.		
November 1	23.5	20.0	May 30	31.5	19.5
November 8	25.5	19.0	June 6	34.0	21.0
November 15	25.0	21.0	June 13	34.0	20.0
November 22	29.0	18.0	June 20	34.5	19.0
November 29	30.0	18.0	June 27	35.0	19.5
December 6	30.5	17.5	July 4	32.0	19.5
December 13	26.0	15.5	July 11	30.5	21.5
December 20	32.0	16.5	July 18	30.0	19.5
December 27	32.0	18.0	July 25	28.0	19.0
1913.			August 1	25.0	18.5
January 3	27.0	18.5	August 8	27.0	18.0
January 10	27.0	18.0	August 15	27.0	18.5
January 17	27.0	17.0	August 22	31.5	19.0
January 24	30.5	17.0	August 29	31.5	18.5
January 31	29.0	14.0	September 5	27.5	18.5
February 7	32.5	16.0	September 12	28.0	18.5
February 14	34.0	17.5	September 19	31.0	20.0
February 21	27.5	16.5	September 26	33.5	18.5
February 28	36.0	17.5	October 3	35.0	19.0
March 7	32.0	17.0	October 10	31.5	19.0
March 14	36.5	11.5	October 17	29.0	18.0
March 21	35.0	19.0	October 24	29.5	17.5
March 28	35.5	17.5	October 31	31.5	16.5
April 4	33.0	18.0	November 7	26.0	19.0
April 11	34.5	17.0	November 14	27.0	16.0
April 18	32.0	19.5	November 21	27.5	17.5
April 25	29.0	19.0	November 28	26.0	16.5
May 2	25.5	19.0	December 5	29.5	18.0
May 9	26.0	19.0	December 12	24.5	18.5
May 16	33.5	19.0	December 19	27.5	18.5
May 23	34.5	19.5	December 26	27.1	17.9

TABLE LXXVI.—*Temperature for weekly periods in the top of a dominant tree in the midmountain forest on Mount Maquiling; altitude, 740 meters*—Continued.

Week ending—	Maximum.	Minimum.	Week ending—	Maximum.	Minimum.
1914.			1914.		
January 2	25.5	17.0	July 10	26.5	18.0
January 9		14.0	July 17	30.2	18.5
January 16		14.0	July 24	32.5	19.0
January 23		16.0	July 31	32.4	18.9
January 30	29.9	16.0	August 7	34.5	19.0
February 6	33.5	16.0	August 14	30.5	18.5
February 13	29.0	15.5	August 21	32.0	18.8
February 20	31.0	15.0	August 28	24.9	19.2
February 27	32.0	15.1	September 4	23.5	19.0
March 6	32.5	17.0	September 11	24.5	19.0
March 13	35.2	16.0	September 18	32.5	17.1
March 20	34.0	17.9	September 25	32.0	18.5
March 27	33.5	17.0	October 2	31.0	21.0
April 3	34.5	17.1	October 9	31.5	18.5
April 10	32.5	18.0	October 16	32.8	18.2
April 17	34.5	18.0	October 23	28.0	17.9
April 24	36.0	18.5	October 30	27.5	18.0
May 1	36.3	18.9	November 6	29.5	18.9
May 8	35.0	20.0	November 13	28.0	19.0
May 15	37.1	18.5	November 20	30.0	19.0
May 22	34.2	19.1	November 27	29.5	19.0
May 29	36.1	20.1	December 4	25.0	18.0
June 5	35.5	19.0	December 11	25.5	18.3
June 12	33.8	20.0	December 18	29.0	17.0
June 19	37.0	19.0	December 25	29.0	18.0
June 26	32.5	19.5	1915.		
July 3	32.0	19.0	January 1	23.5	17.0

The weekly maximum and minimum temperatures in the top of the dominant tree are given in Table LXXVI. In Table LXXVII these results are averaged for corresponding four-week periods for the entire period, and in the same table are also given similar figures for temperatures in the undergrowth. In this table, as in similar comparison tables for lower elevations, the average maximum temperature was considerably higher in the dominant tree than in the undergrowth, being in the former case 30.4°, and in the latter, 24.3°. The minimum temperatures are again much more alike. The average weekly minimum temperature for the dominant tree (18.1°) is slightly lower than that in the undergrowth (19.4°). The absolute maximum temperature in the dominant tree occurred during the week ending June 19, 1914, and was 37.0°, and in the undergrowth it was 27.5° on May 25, 1914. The absolute minimum temperature in the top of the tree was 11.5° and was recorded during the week ending

TABLE LXXVII.—*Average of weekly maximum and minimum temperatures for periods of four weeks from October, 1912, to January, 1915, in the midmountain forest on Mount Maquiling; altitude, 740 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	In undergrowth.		In dominant tree.	
	Maximum.	Minimum.	Maximum.	Minimum.
January 31	21.7	17.2	28.4	15.8
February 28	22.3	17.2	32.5	16.2
March 28	24.5	18.8	34.8	16.7
April 25	25.0	19.5	32.1	18.2
May 23	25.9	21.0	29.9	19.1
June 20	26.6	20.9	33.5	19.7
July 18	25.5	20.5	31.9	19.4
August 15	24.5	20.3	26.8	18.7
September 12	24.4	20.0	29.6	18.8
October 10	25.6	20.4	32.8	19.0
November 7	23.7	19.3	26.8	18.5
December 5	23.1	18.7	28.1	18.1
January 2	22.5	18.5	27.8	17.6
Average	24.3	19.4	30.4	18.1

March 14, 1913, and in the undergrowth it was 15.5°, on January 9 and 10, 1914.

TEMPERATURE IN THE MOSSY FOREST

The temperature in the mossy forest was recorded on the top of the east peak at an elevation of 1,050 meters. As in the midmountain forest, the temperature under the trees was taken by means of a Draper recording thermometer, and in the top of the dominant tree, by means of maximum and minimum thermometers. The temperatures under the trees are given in Table LXXVIII in the form of weekly maxima, weekly minima, means, and averages of daily maxima and minima. These results are summarized, for corresponding four-week periods for the entire period, in Table LXXIX. The mean temperature for the whole period was 17.8°; the absolute maximum, 26.1°; the absolute minimum, 12.2°; the average daily maximum, 19.3°; and the average daily minimum, 16.9°. These temperatures are considerably lower than those in the midmountain forest, but the ranges are very similar. The average daily range in the mossy forest was 2.4°, and in the midmountain forest, 2.6°. The extreme range in the mossy forest was 13.9°, and in the midmountain forest, 12°. The mean temperature for the entire period was 3.6° higher in the midmountain than in the mossy forest.

TABLE LXXVIII.—*Temperature for weekly periods under the mossy forest at the top of Mount Maquiling; altitude, 1,050 meters.*

[Numbers give degrees centigrade.]

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1912.					
October 25	19.4	16.6	17.8	18.7	17.4
November 1	22.0	16.9	19.2	20.4	18.0
November 8	21.4	17.1	18.8	19.8	17.9
November 15	20.5	17.1	18.3	19.4	17.8
November 22	21.1	16.6	17.8	19.4	17.4
November 29	20.3	16.0	18.1	19.1	17.0
December 6	20.5	15.5	17.5	19.4	16.5
December 13	18.3	13.9	16.5	17.5	15.6
December 20	19.7	14.8	17.1	18.7	16.3
1913.					
January 3	19.2	14.2	16.5	17.6	15.5
January 10	19.4	16.0	17.1	18.3	16.9
January 17	20.3	16.0	17.2	19.0	16.7
January 24	20.3	15.0	17.1	19.0	16.1
January 31	17.1	13.9	15.3	16.5	15.1
February 7	19.7	14.5	17.2	18.4	16.0
February 14	20.3	14.2	16.0	17.9	15.4
February 21	18.9	14.8	16.5	17.5	15.9
February 28	19.2	12.8	16.0	18.1	15.5
March 7	19.7	15.5	16.9	18.2	16.1
March 14	21.1	13.9	18.2	20.3	17.1
March 21	22.2	15.5	17.3	19.4	16.2
March 28	21.7	14.8	17.2	19.6	16.1
April 4	20.0	13.3	17.0	18.8	15.7
April 11	21.1	15.3	17.7	20.1	16.0
April 18	21.7	16.9	18.4	20.3	17.6
April 25	20.0	16.0	18.2	19.6	17.2
May 2	20.0	16.9	18.3	19.3	17.5
May 9	20.8	17.1	18.7	19.3	17.9
May 16	23.0	16.9	19.5	22.2	17.6
May 23	23.3	17.4	19.3	21.3	18.1
May 30	21.7	17.7	19.3	21.0	18.5
June 6	23.9	18.0	19.8	21.4	18.8
June 13	23.9	16.9	19.9	22.9	18.2
June 20	23.9	17.1	19.4	22.1	18.5
June 27	23.3	16.9	19.3	21.8	18.0
July 4	22.5	17.1	19.4	21.1	18.2
July 11	22.0	17.1	19.1	21.0	17.9
July 18	21.4	17.1	18.7	19.8	18.4
July 25	20.0	17.4	18.4	19.1	17.8
August 1	20.3	17.1	17.9	19.5	17.6
August 8	20.0	16.0	17.7	19.1	17.3
August 15	20.8	16.3	18.4	19.8	17.5
August 22	21.7	16.0	18.7	19.3	17.5
August 29	21.4	16.6	18.1	19.9	17.2
September 5	20.8	15.8	18.2	19.6	17.1
September 12	22.2	16.6	18.4	20.2	18.1

TABLE LXXVIII.—*Temperature for weekly periods under the mossy forest at the top of Mount Maquiling; altitude, 1,050 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
1913.					
September 19	23.0	17.7	18.8	20.7	18.5
September 26	22.0	16.9	19.2	20.6	18.0
October 3	21.4	16.0	18.7	20.6	17.3
October 10	20.0	16.0	18.2	19.4	17.5
October 17	19.7	15.5	17.9	19.2	17.1
October 24	19.7	16.0	17.0	18.9	16.6
October 31	19.2	14.5	17.0	17.7	16.3
November 7	20.5	16.0	18.4	19.2	18.0
November 14	19.7	13.9	17.6	18.2	16.9
November 21	19.4	15.0	16.6	17.6	16.1
November 28	19.2	15.5	16.1	16.9	17.2
December 5	18.9	15.0	16.6	17.9	16.0
December 12	19.4	15.5	16.9	17.6	16.5
December 19	19.2	15.8	17.1	18.0	16.5
December 26	19.7	16.0	17.7	18.2	16.7
1914.					
January 2	18.9	13.9	15.6	16.9	15.3
January 9	17.4	12.8	14.9	15.7	14.3
January 16	16.9	12.2	14.9	15.9	14.3
January 23	17.4	13.9	15.4	16.5	14.8
January 30	16.9	13.3	15.1	16.0	14.3
February 6	18.6	14.8	15.8	17.2	15.7
February 13	16.9	12.8	15.1	16.2	14.6
February 20	17.1	13.3	15.0	16.0	14.9
February 27	19.4	13.1	15.7	18.0	14.4
March 6	20.5	13.9	16.2	17.8	15.5
March 13	21.1	14.5	17.2	19.3	16.1
March 20	20.8	15.8	16.6	17.9	16.2
March 27	19.4	15.0	16.8	18.1	15.8
April 3	19.2	14.5	17.2	19.9	15.7
April 10	20.5	16.0	17.8	19.1	17.1
April 17	21.2	15.5	18.5	19.9	16.9
April 24	22.3	17.1	18.9	20.5	17.5
May 1	21.7	16.0	18.7	20.3	17.1
May 8	21.1	17.1	18.9	20.1	17.7
May 15	22.2	17.1	19.5	21.0	18.4
May 22	22.6	17.4	19.6	21.8	18.0
May 29	23.3	17.1	20.2	22.1	18.2
June 5	23.9	16.9	19.1	20.7	17.8
June 12	23.9	17.1	20.5	22.4	18.5
June 19	23.3	16.6	19.1	20.6	18.1
June 26	22.7	17.1	19.4	21.2	18.9
July 3	23.3	17.1	18.9	21.5	18.4
July 10	26.1	18.3	20.7	22.6	20.6
July 17	20.0	16.6	19.0	19.5	17.6
July 24	22.0	14.8	18.2	19.8	17.0
July 31	19.4	14.2	16.7	18.1	15.9
August 7	22.3	15.6	17.6	20.6	16.9

TABLE LXXVIII.—*Temperature for weekly periods under the mossy forest at the top of Mount Maquiling; altitude, 1,050 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
1914.					
August 14	19.7	15.3	17.5	18.4	16.4
August 21	21.4	14.8	18.0	19.8	16.7
August 28	18.6	15.3	17.2	18.0	17.0
September 4	18.9	15.9	17.6	18.3	17.1
September 11	18.6	15.9	17.5	18.1	17.1
September 18	19.1	13.7	17.0	18.5	15.5
September 25	23.7	16.5	18.2	21.1	17.1
October 2	22.5	15.3	17.7	20.1	16.2
October 9	22.0	16.2	17.6	19.6	16.9
October 16	18.6	15.3	17.0	17.7	16.3
October 23	18.9	15.9	17.1	17.8	16.6
October 30	18.9	15.9	16.6	17.8	14.4
November 6	18.9	14.8	15.2	18.1	17.1
November 13	19.4	13.6	17.5	18.1	16.8
November 20	19.1	14.8	17.5	18.1	16.4
November 27	19.4	15.3	17.6	18.1	17.0
December 4	19.1	16.5	17.6	18.1	17.2
December 11	18.9	16.4	17.4	18.0	16.9
December 18	18.5	15.1	17.2	17.7	16.4
December 25	20.3	15.9	17.3	18.4	16.5
1915.					
January 1	18.0	14.8	16.2	17.0	15.7

TABLE LXXIX.—*Temperature for periods of four weeks from November, 1912, to January, 1915, under the mossy forest at the top of Mount Maquiling; altitude, 1,050 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
January 31	20.3	12.2	15.9	17.1	15.3
February 28	20.3	12.8	15.9	17.4	15.3
March 28	22.2	13.9	17.1	18.9	16.2
April 25	22.3	13.3	18.0	19.8	16.7
May 23	23.3	16.0	19.1	20.7	17.8
June 20	23.9	16.6	19.7	21.9	18.3
July 18	26.1	16.6	19.3	21.1	18.5
August 15	22.3	14.2	17.8	19.3	17.1
September 12	22.2	14.8	18.0	19.2	17.3
October 10	23.7	13.7	18.2	20.1	17.1
November 7	22.0	14.5	17.6	18.7	17.0
December 5	21.1	13.6	17.4	18.3	16.9
January 2	20.3	13.9	16.8	17.8	16.1
Average	22.3	14.3	17.8	19.3	16.9

Table LXXX records the weekly maximum and minimum temperatures in the top of the dominant tree. The absolute maximum was 39.5°, and the minimum, 9.5°.

The results of Table LXXX are summarized for corresponding four-week periods for the different years in Table LXXXI, in which table are also given similar figures for temperatures under the trees. As in previous cases the maximum temperature in the dominant tree was higher than that under the trees, the average weekly maximum being 28.1° in the top of the tree and 20.6° in the undergrowth. The minimum temperatures show a different condition from that found at any lower elevation in the virgin forest, the average minimum under the trees being lower than in the top of the dominant tree. The average minimum in the first case was 15.7°, and in the latter, 17.3°.

TABLE LXXX.—*Temperature for weekly periods in the top of a dominant tree in the mossy forest on Mount Maquiling; altitude, 1,050 meters.*

[Numbers give degrees centigrade.]

Week ending—	Maximum.	Minimum.	Week ending—	Maximum.	Minimum.
1912.			1913.		
October 18	21.5	17.5	May 9	22.0	19.0
October 25	21.5	18.0	May 16	32.0	18.0
November 1	22.5	18.5	May 23	33.5	18.5
November 8	26.5	18.5	May 30	28.0	19.0
November 15	26.0	18.5	June 6	30.5	20.0
November 22	29.5	17.5	June 13	31.0	18.5
November 29	25.0	17.0	June 20	33.5	18.5
December 6	25.0	16.5	June 27	30.5	18.0
December 13	26.0	14.5	July 4	30.0	18.5
December 20	30.0	15.0	July 11	31.0	19.0
December 27	28.0	16.0	July 18	22.5	20.5
1913.			July 25	21.5	18.5
January 3	27.5	18.0	August 1	21.5	18.0
January 10	28.0	18.0	August 8	27.5	21.5
January 17	30.0	16.5	August 15	23.0	18.0
January 24	37.5	17.0	August 22	23.5	18.0
January 31	22.0	14.0	August 29	26.5	18.5
February 7	26.5	15.5	September 5	26.5	17.0
February 14	35.5	16.5	September 12	27.5	18.5
February 21	29.0	16.0	September 19	31.5	18.5
February 28	37.0	16.5	September 26	28.5	18.0
March 7	33.0	10.5	October 3	30.0	17.5
March 14	39.5	9.5	October 10	29.0	18.5
March 21	35.0	16.5	October 17	26.0	17.5
March 28	32.5	16.5	October 24	29.5	16.5
April 4	28.0	16.0	October 31	23.5	15.5
April 11	28.0	17.0	November 7	21.5	17.5
April 18	27.0	19.0	November 14	21.5	15.0
April 25	26.0	18.0	November 21	20.5	17.5
May 2	24.5	18.0	November 28	25.5	15.5

TABLE LXXX.—*Temperature for weekly periods in the top of a dominant tree in the mossy forest on Mount Maquiling; altitude, 1,050 meters*—Continued.

Week ending—	Maximum.	Minimum.	Week ending—	Maximum.	Minimum.
1913.			1914.		
December 5	27.5	17.5	June 26		17.6
December 12	21.5	18.0	July 3		17.0
December 19	23.5	18.0	July 10		17.9
December 26	27.5	16.5	July 17		17.5
1914.			July 24		27.5
January 2	26.0	16.5	July 31		17.1
January 9		13.5	August 7		16.5
January 16		13.9	August 14		17.5
January 23		14.5	August 21		18.2
January 30		15.0	August 28		19.0
February 6		15.2	September 4		18.0
February 13		14.1	September 11		18.0
February 20		14.0	September 18		14.0
February 27		15.0	September 25		17.5
March 6		16.0	October 2		17.9
March 13		15.5	October 9		17.9
March 20		17.0	October 16		17.5
March 27		16.0	October 23		17.0
April 3		15.9	October 30		17.0
April 10		17.5	November 6		17.0
April 17		17.5	November 13		18.0
April 24		18.0	November 20		18.0
May 1		27.5	November 27		18.0
May 8		17.5	December 4		18.0
May 15		18.5	December 11		17.0
May 22		18.0	December 18		16.2
May 29		18.0	December 25		17.0
June 5		18.5	1915.		
June 12		18.0	January 1		17.0
June 19		18.9			

The most obvious explanation of the fact that the temperature in the undergrowth is lower than in the dominant tree at this elevation and higher at lower elevations is that this station, being on the top of an isolated peak, was not so exposed to the downward sweep of cold winds as were the stations at lower elevations.

COMPARISON OF TEMPERATURES AT DIFFERENT ELEVATIONS

In order that the temperatures at different elevations might be conveniently compared, the maxima, minima, means, average daily maxima and minima, and in the cases of the maximum and minimum thermometers, the average weekly maxima and minima for corresponding four-week periods, have been brought together in a series of tables and curves.

TABLE LXXXI.—*Average of weekly maximum and minimum temperatures for periods of four weeks from October, 1912, to January, 1915, in the mossy forest at the summit of Mount Maquiling; altitude, 1,050 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	In undergrowth.		In dominant tree.	
	Maximum.	Minimum.	Maximum.	Minimum.
January 31	18.3	14.2	29.4	15.3
February 28	18.8	13.8	32.0	15.4
March 28	20.9	14.9	35.0	14.7
April 25	20.8	15.6	27.3	17.4
May 23	21.9	17.0	28.0	18.2
June 20	23.5	17.2	30.8	18.7
July 18	22.7	17.2	28.5	18.3
August 15	20.6	15.9	23.4	19.4
September 12	20.4	15.9	26.0	18.2
October 10	21.7	16.1	29.8	17.5
November 7	19.8	15.7	24.1	17.3
December 5	19.7	15.4	25.1	17.3
January 2	19.1	15.1	26.3	16.7
Average	20.6	15.7	28.1	17.3

TABLE LXXXII.—*Mean temperature for periods of four weeks from October, 1912, to January, 1915, under trees at different elevations on Mount Maquiling.*

[Numbers give degrees centigrade.]

Four weeks ending—	Elevation in meters.				
	80.	300.	450.	740.	1,050.
January 31	24.0	21.2	20.1	19.3	15.9
February 28	24.4	21.5	20.7	19.3	15.9
March 28	27.0	22.9	22.8	21.3	17.1
April 25	27.2	23.9	23.7	21.9	18.0
May 23	27.7	24.7	25.1	23.0	19.1
June 20	27.7	25.0	24.5	23.1	19.7
July 18	26.9	24.0	23.7	22.3	19.3
August 15	26.2	23.5	23.3	21.9	17.8
September 12	26.6	23.6	23.0	21.9	18.0
October 10	25.9	23.3	23.3	22.4	18.2
November 7	25.7	22.9	22.4	21.2	17.6
December 5	25.6	22.6	22.1	20.6	17.4
January 2	24.7	21.8	21.5	19.9	16.8
Average	26.1	23.1	22.8	21.4	17.8

The mean temperatures under the trees at different elevations are presented in Table LXXXII and plotted in fig. 8. The temperatures for the dipterocarp forest at an elevation of 450

meters do not cover as long a period as do those at other elevations, and perhaps owing to this fact they show some minor variations. The curve for this elevation is omitted in the following discussion.

Fig. 8 shows that in all cases the lowest mean was in January or February, after which the temperature rose, reaching a maximum during the period ending June 20. The mean then became lower until the period ending August 15, after which there was another rise, a second but lower maximum occurring during the period ending September 12 or October 10, after which the temperature again fell. The low point in the curve for the period ending August 15 is apparently connected with the occurrence of the rainy season, as there is much more rain during this season than at any other time, and the sky is frequently overcast by clouds. A comparison of these curves for temperature with those which will be given later for light would seem to indicate that the variations in temperature are caused largely by variations in light intensity at different periods.

One of the most striking things brought out by these curves is the similarity in the range of temperature at different elevations. In the parang at an elevation of 80 meters the greatest difference between the mean temperatures for any corresponding four-week period was 3.7°; in the dipterocarp forest at an elevation of 300 meters, 3.8°; in the midmountain forest at an elevation of 740 meters, 3.8°; and in the mossy forest, 3.8°. The range for four-week periods is, therefore, exactly the same in the mossy forest, the midmountain forest, and the dipterocarp forest at an elevation of 300 meters; while in the parang it is 0.1° less than at the higher altitudes. The mean temperature for the entire period at an elevation of 80 meters is 26.1°; at 300 meters, 23.1°; at 450 meters, 22.8°; at 740 meters, 21.4°; and at 1,050 meters, 17.8°.

The average daily minimum temperatures under the forest for corresponding four-week periods at different elevations are given in Table LXXXIII, and the average daily maxima are given in Table LXXXIV. In fig. 9 the yearly means, yearly average daily maxima, and yearly average daily minima for the different stations are plotted in separate curves. These curves show at once that the greatest average daily range is at an elevation of 80 meters, and that the daily range decreases as higher altitudes are reached. The average daily range for the parang is 5.5°; in the dipterocarp forest at an elevation of 300 meters, 3.4°; in the dipterocarp forest at an elevation of 450 meters,

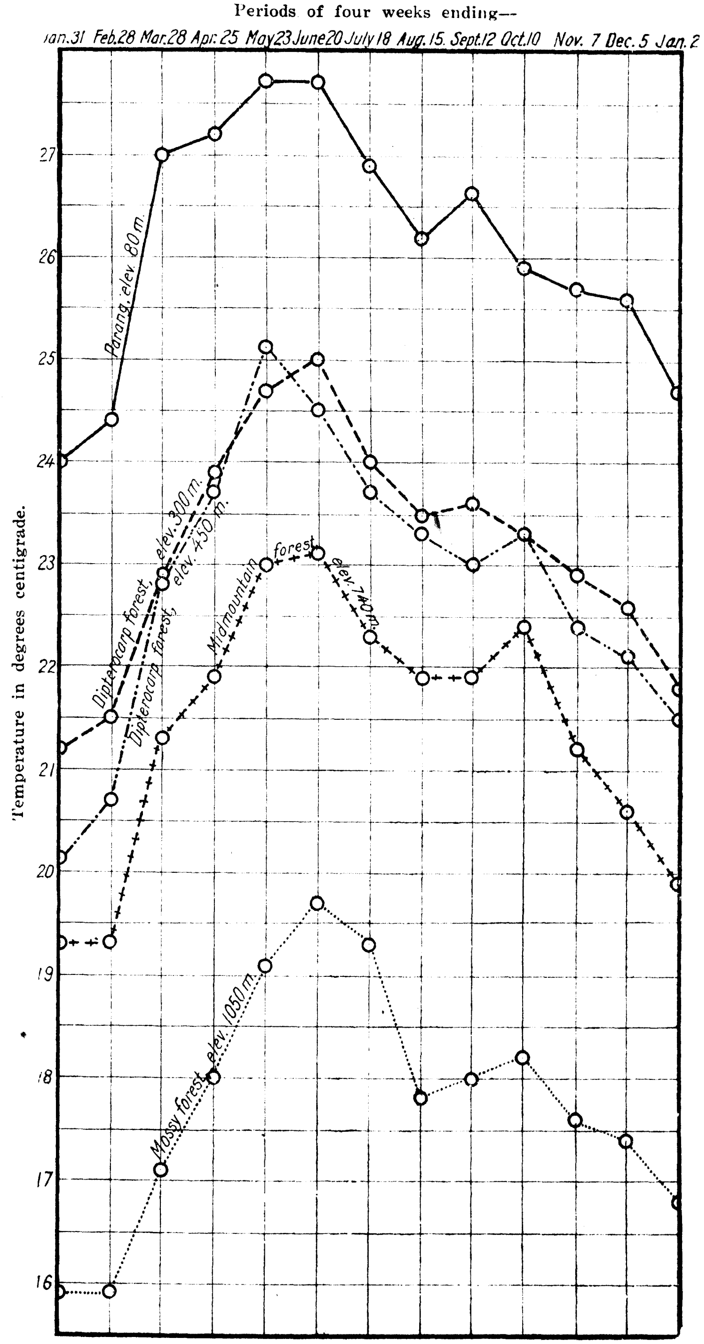

Fig. 8. Mean temperature under trees at different altitudes on Mount Maquiling.

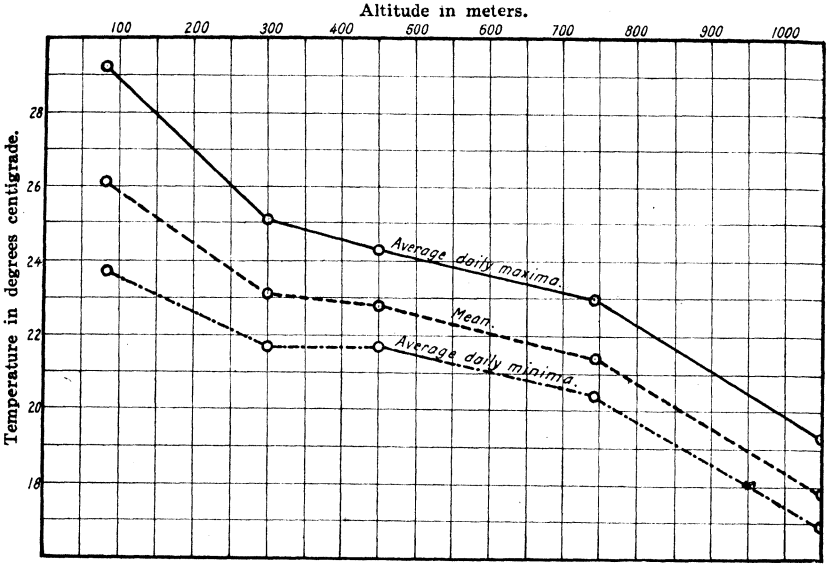

FIG. 9. Average daily maxima and minima and mean temperatures under trees at different altitudes on Mount Maquiling.

TABLE LXXXIII.—*Averages of daily minimum temperature for periods of four weeks from October, 1912, to January, 1915, under trees at different elevations on Mount Maquiling.*

[Numbers give degrees centigrade.]

Four weeks ending—	Elevation in meters.				
	80.	300.	450.	740.	1,050.
January 31	22.0	20.0	19.2	18.4	15.3
February 28	21.9	19.8	19.5	18.2	15.3
March 28	23.4	21.8	21.1	19.7	16.2
April 25	23.6	21.9	22.2	20.4	16.7
May 23	24.4	22.6	23.3	21.5	17.8
June 20	24.5	22.6	23.0	21.8	18.3
July 18	24.9	22.6	22.7	21.6	18.5
August 15	24.2	22.2	22.5	21.0	17.1
September 12	24.5	22.2	22.1	21.0	17.3
October 10	23.9	21.8	22.2	21.3	17.1
November 7	23.7	21.9	21.7	20.3	17.0
December 5	23.7	21.6	21.4	20.1	16.9
January 2	23.0	20.8	20.7	19.5	16.1
Average	23.7	21.7	21.7	20.4	16.9

2.6°; in the midmountain forest, 2.6°; and in the mossy forest, 2.4°.

The curves for the average daily maximum, mean, and average daily minimum for different elevations have the same general

TABLE LXXXIV.—*Averages of daily maximum temperature for periods of four weeks from October, 1912, to January, 1915, under trees at different elevations on Mount Maquiling.*

[Numbers give degrees centigrade.]

Four weeks ending—	Elevation in meters.				
	80.	300.	450.	740.	1,050.
January 31	26.7	22.5	21.5	20.7	17.1
February 28	28.0	23.2	22.4	20.9	17.4
March 28	30.7	25.8	24.7	23.1	18.9
April 25	30.7	26.6	25.8	23.9	19.8
May 23	31.5	27.4	26.8	24.9	20.7
June 20	31.7	27.0	26.2	25.3	21.9
July 18	29.8	25.9	25.0	24.2	21.1
August 15	28.9	25.5	24.6	23.4	19.3
September 12	29.0	25.4	24.4	23.1	19.2
October 10	29.4	25.5	25.2	24.2	20.1
November 7	28.0	24.6	24.0	22.5	18.7
December 5	27.8	24.1	23.4	22.0	18.3
January 2	27.0	23.0	22.5	21.3	17.8
Average	29.2	25.1	24.3	23.0	19.3

form. They show that the fall in temperature in proportion to the rise in elevation was much greater between the parang and the dipterocarp forest at 300 meters than it was between the latter station and the midmountain forest, while the fall was more rapid in proportion to the rise in elevation between the midmountain forest and the mossy forest on the top of the mountain than it was between the dipterocarp forest at 300 meters' elevation and the midmountain forest at 740 meters' altitude.

The great difference in temperature in the parang and the dipterocarp forest is very probably connected with the fact that this latter forest keeps almost all of the direct sunlight from reaching the ground, and also prevents a free movement of the warm winds coming from lower elevations, while the large leaf surface exposed to evaporation has a considerable tendency to cool the atmosphere. It will be noted that the curve for the maximum temperatures has the steepest slope between elevations of 80 and 300 meters, while the curve for the average daily minima is less steep than either of the other two. This is very natural and is due to the fact that under the forest the heating effect of the sun, which causes high maximum temperatures, is greatly minimized. This would of course account for the low average daily maxima in the dipterocarp forest and also for the lower average mean.

Between the two stations in the dipterocarp forest there is less

difference, as compared with the difference in altitude, in the mean and average daily maximum than there is between stations at higher elevations; while the differences in average daily maxima, means, and average daily minima, as compared with elevation, are greater between the midmountain forest and mossy forest than between the stations in the dipterocarp forest and the midmountain forest. This would seem to indicate that a dense dipterocarp forest has an equalizing effect on the temperature, whereas as high elevations are reached the undergrowth is less protected from atmospheric changes outside of the forest. This is due to the fact that, as higher elevations are reached, the forest becomes progressively lower and more open.

Maximum and minimum temperatures for corresponding four-week periods in the undergrowth are given in Tables LXXXV and LXXXVI.

TABLE LXXXV.—*Maximum temperature for periods of four weeks from October, 1912, to January, 1915, under trees at different elevations on Mount Maquiling.*

[Numbers give degrees centigrade.]

Four weeks ending—	Elevation in meters.				
	80.	300.	450.	740.	1,050.
January 31	29.0	24.8	23.0	22.7	20.3
February 28	31.5	25.6	24.5	22.7	20.3
March 28	33.5	27.7	26.6	25.9	22.2
April 25	33.8	28.3	27.5	25.6	22.3
May 23	34.6	29.4	28.3	27.2	23.3
June 20	34.0	29.7	28.6	27.5	23.9
July 18	32.0	28.0	26.1	26.6	26.1
August 15	31.4	28.0	28.0	27.2	22.3
September 12	31.0	27.5	26.6	25.9	22.2
October 10	32.0	27.7	27.5	26.6	23.7
November 7	30.6	26.6	25.6	24.2	22.0
December 5	31.1	25.9	24.9	23.9	21.1
January 2	29.7	25.0	23.9	23.6	20.3
Average	31.9	27.2	26.2	25.4	22.3

CALCULATION OF MEAN TEMPERATURES FROM MAXIMUM AND MINIMUM TEMPERATURES

Where it is inconvenient to use recording instruments, mean temperatures are very frequently calculated from the averages of maximum and minimum temperatures, and so it may be of interest here to see how closely a mean calculated from averages of maxima and minima corresponds with the mean as observed. In Table LXXXVII such a calculation is made for temperatures

TABLE LXXXVI.—*Minimum temperature for periods of four weeks from October, 1912, to January, 1915, under trees at different elevations on Mount Maquiling.*

[Numbers give degrees centigrade.]

Four weeks ending—	Elevation in meters.					
	80.	300.	450.	740.	900.	1,050.
January 31	20.0	16.6	17.2	15.5	15.0	12.2
February 28	20.0	17.4	18.6	16.6	15.0	12.8
March 28	20.8	18.9	19.7	18.0	15.5	13.9
April 25	19.6	19.4	20.3	18.3	16.0	13.3
May 23	22.3	20.5	22.5	20.0	18.0	16.0
June 20	22.0	18.9	20.5	18.9	18.9	16.6
July 18	22.5	20.5	20.5	18.3	17.5	16.6
August 15	22.0	19.4	20.8	19.4	18.0	14.2
September 12	22.0	20.5	20.0	19.4	17.5	14.8
October 10	21.8	19.7	20.5	19.4	17.0	13.7
November 7	21.0	19.4	20.0	18.3	17.0	14.5
December 5	22.0	19.4	19.7	15.5	16.5	13.6
January 2	19.9	19.2	18.9	16.3	16.0	13.9
Average	21.2	19.2	19.9	18.0	16.8	14.3

at the base of the mountain. In this table are given the average daily maxima and minima for the years 1912, 1913, and 1914; the mean calculated from the averages of maxima and minima; the observed mean; and the differences between the calculated mean and the observed mean. The table shows that the average difference between the calculated mean and the observed mean for the entire period was 0.2°, whereas the average daily range was 5.8°. The error in calculating the mean from the daily maxima and minima would in this case be small. It is, how ever, 3.4 per cent of the average daily range.

TABLE LXXXVII.—*Calculation of mean temperature at the base of Mount Maquiling, from average of daily maxima and minima as compared with observed mean.*

[Numbers give degrees centigrade.]

Year.	Average daily maxima.	Average daily minima.	Average maxima and minima.	Mean.	Difference between calculated and observed mean.
1912	29.2	22.7	25.95	25.9	0.05
1913	28.6	23.2	25.9	25.6	0.3
1914	29.7	24.2	26.95	26.7	0.25
Average	29.2	23.4	26.3	26.1	0.2

TABLE LXXXVIII.—*Calculation of mean temperature under trees from average of daily maxima and minima as compared with observed mean at different elevations on Mount Maquiling.*

[Numbers give degrees centigrade.]

Year.	Elevation in meters.							
	80.		300.		450.			
					Under trees.		In open.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
1913	28.6	23.2	25.1	21.6	23.9	21.8		
1914	29.7	24.3	25.1	21.6	24.4	21.6	27.8	22.0
Average	29.15	23.75	25.1	21.6	24.15	21.7		
Average of maximum and minimum	26.45		23.35		22.9		24.9	
Mean	26.15		23.1		22.7		24.2	
Difference	0.3		0.25		0.2		0.7	

Year.	Elevation in meters.			
	740.		1,050.	
	Maximum.	Minimum.	Maximum.	Minimum.
1913	22.8	20.2	19.4	17.1
1914	23.3	20.6	18.9	16.6
Average	23.05	20.4	19.15	16.85
Average of maximum and minimum	21.7		18.0	
Mean	21.4		17.65	
Difference	0.3		0.35	

In Table LXXXVIII are given similar calculations for the different elevations for the years 1913 and 1914. For these years the error in the parang was 0.3°; in the dipterocarp forest at 300 meters' elevation, 0.25°; in the dipterocarp forest at 450 meters, 0.2°; in the open at 450 meters, 0.7°; in the mid-mountain forest at 740 meters, 0.3°; and in the mossy forest at 1,050 meters, 0.35°. All these differences, except that in the open, appear small. The error in the case of the mossy forest is, however, 15 per cent of the average daily range; in the mid-mountain forest, 11 per cent; in the dipterocarp forest at 450 meters' elevation, 8 per cent; and in the dipterocarp forest at 300 meters' elevation, 7 per cent. The actual differences between

the mean temperatures as calculated from the average daily maxima and minima and the mean as observed were, therefore, small in degree, but considerable in proportion to the total range.

The error in the case of the clearing at 450 meters' altitude is no greater in proportion to the range than in some of the other cases, being 12 per cent. As in ecological work it is frequently possible to use only maximum and minimum thermometers and to read these not oftener than once a week, it may be of interest to see how close the averages of weekly maxima and minima come to the true mean. The results of such a calculation are given in Table LXXXIX. The actual differences in most cases are not very much greater than when the mean is calculated from average daily maxima and minima.

TABLE LXXXIX.—*Calculation of mean temperature under trees from average of weekly maxima and minima as compared with observed mean at different elevations on Mount Maquiling.*

[Numbers give degrees centigrade.]

Year.	Elevation in meters.									
	80.		300.		450.		740.		1,050.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
1913	29.9	22.2	26.3	20.7	25.0	20.9	24.0	19.3	20.7	15.9
1914	31.0	23.3	26.2	20.5	25.5	20.8	24.5	19.6	20.3	15.4
Average	30.45	22.75	26.25	20.6	25.25	20.85	24.25	19.45	20.5	15.65
Average of maximum and minimum	26.60		23.40		23.05		21.85		18.20	
Mean	26.15		23.10		22.70		21.40		17.65	
Difference	0.45		0.3		0.3		0.4		0.55	

It is to be noted that all of these errors are in the same direction, and so it would seem that when working with maximum and minimum thermometers in forests in which conditions are similar to those on Mount Maquiling fairly accurate means could be obtained from averages of weekly maxima and minima. The similarity between the mean calculated from the average maxima and minima and the mean observed is, however, very probably due in part to the fact that the ranges in temperature are slight.

The average weekly maximum and minimum temperatures for corresponding four-week periods in the tops of the dominant trees at different elevations are given in Table XC. The results are plotted in fig. 10.

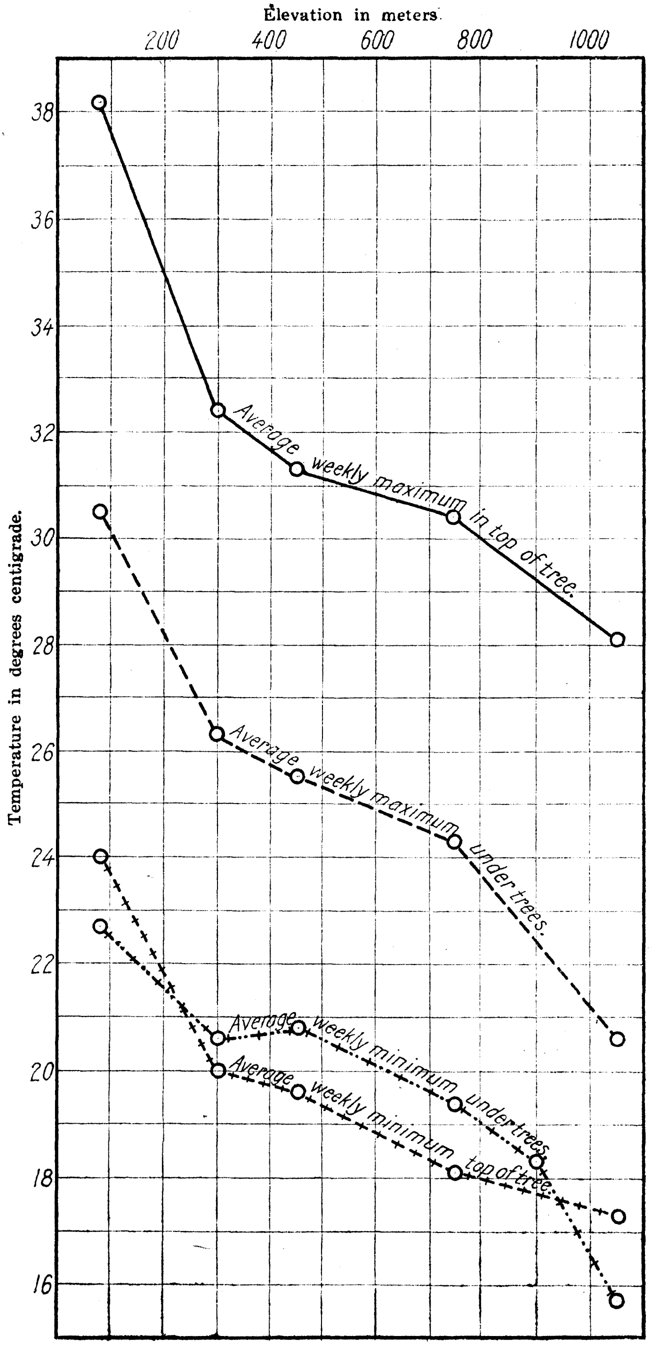

FIG. 10. Average of weekly maximum and minimum temperatures at different altitudes on Mount Maquiling.

TABLE XC.—*Average of weekly maximum and minimum temperatures for periods of four weeks from October, 1912, to January, 1915, in the tops of tall trees at different elevations on Mount Maquiling.*

[Numbers give degrees centigrade.]

MAXIMA.

Four weeks ending—	Elevation in meters.				
	80.	300.	450.	740.	1,050.
January 31	36.5	30.1	27.6	28.4	29.4
February 28	36.5	31.6	30.4	32.5	32.0
March 28	37.7	34.8	31.0	34.8	35.0
April 25	37.3	31.9	31.7	32.1	27.3
May 23	38.0	33.7	32.1	29.9	28.0
June 20	39.4	35.3	33.6	33.5	30.8
July 18	38.8	33.2	31.1	31.9	28.5
August 15	41.2	31.8	32.8	26.8	23.4
September 12	38.5	31.1	30.0	29.6	26.0
October 10	41.1	36.1	32.9	32.8	29.8
November 7	38.4	31.4	32.3	26.8	24.1
December 5	37.1	29.7	30.8	28.1	25.1
January 2	36.2	29.9	30.3	27.8	26.3
Average	38.2	32.4	31.3	30.4	28.1

MINIMA.

Four weeks ending—	80.	300.	450.	740.	1,050.
January 31	22.2	17.9	17.2	15.8	15.3
February 28	21.8	18.3	18.2	16.2	15.4
March 28	23.5	20.0	19.3	16.7	14.7
April 25	24.1	19.9	20.1	18.2	17.4
May 23	25.5	21.3	21.7	19.1	18.2
June 20	24.2	21.1	21.2	19.7	18.7
July 18	25.0	20.8	20.4	19.4	18.3
August 15	24.7	20.7	19.7	18.7	19.4
September 12	24.7	20.9	18.8	18.8	18.2
October 10	25.1	20.2	20.3	19.0	17.5
November 7	24.2	20.3	19.5	18.5	17.3
December 5	24.2	19.8	19.0	18.1	17.3
January 2	23.3	19.3	18.8	17.6	16.7
Average	24.0	20.0	19.6	18.1	17.3

RELATION OF TEMPERATURE TO VEGETATION

Lehenbauer * has made an extensive study of the relation of the rate of growth of maize seedlings to temperature. He found that the optimum temperature varied with the length of the exposure. For three-hour exposures it was 29°; for nine or twelve hours it was 32°; while for periods of eighteen or twenty-one hours, and probably for twenty-four or twenty-seven hours,

* Lehenbauer, P. A., Growth of maize seedlings in relation to temperature, *Physiol. Res.* (1914), 1, 247–288.

it was also 32°; for longer periods it appeared to shift to 31°. An examination of Table LXXXII shows that the mean temperature, even at the base of Mount Maquiling, was lower than any of the optima obtained by Lehenbauer, the highest mean temperature in the parang for any corresponding four-week period being 27.7°. From Table LXXXIV it would appear that the average daily maximum at all elevations above 80 meters was also lower than any of the optima obtained by Lehenbauer. At an elevation of 80 meters the highest average daily maximum for any corresponding four-week period was 31.7°, and the lowest, 26.7°. It would seem, therefore, that the average daily maximum temperature at an elevation of 80 meters would be about optimum for the growth of maize seedlings.

A careful study of the influence of temperature on the rates of growth of roots of *Pisum sativum* has been made by Leitch.* According to her results, the optimum temperature appeared to be between 28° and 30°. These figures are not very different from those obtained by Lehenbauer.

The mean temperature at the base of Mount Maquiling was 26.1°, and at the top, 17.8°. According to Lehenbauer's curve for twelve-hour periods, maize seedlings would grow just about three times as fast at the former as at the latter temperature. If this difference is applicable to the rates of growth on Mount Maquiling, it would account for a considerable part, although not for all, of the differences between the rates of growth at the top of the mountain and those at lower elevations. However, when we compare the size of the trees at an elevation of 450 meters (where the exact measurements in the dipterocarp forest were made) with the size of those in the mossy forest, the difference in temperature would account for only about half of the difference in corresponding rates of growth, as the tallest trees in the dipterocarp forest at 450 meters' elevation are about four and one-half times as high as at the top of the mountain. The difference in temperature in these two situations would, according to Lehenbauer's curve, account for an increase in the rate of growth in the dipterocarp forest over that in the mossy forest of about 130 per cent.

Individuals of *Parashorea malaanonan* between 20 and 50 centimeters in diameter at an altitude of 300 meters grow twice as fast as similar-sized individuals of *Astronia pulchra* at an altitude of 740 meters; whereas the temperature, according to Lehen-

* Leitch, I., Some experiments on the influence of temperature on the rate of growth in Pisum sativum, *Ann. Bot.* (1916), **30**, 25–46.

bauer's curve, would account for an increase of only 12 per cent in the rate of growth of *Parashorea* at 300 meters' elevation over that for *Astronia*. Leitch's curve for the relation of temperature to growth shows even smaller differences in the rates of growth for different temperatures than does Lehenbauer's.

In considering the rates of growth as related to temperature it must be remembered, however, that Lehenbauer's and Leitch's seedlings were growing from a reserve food supply, whereas trees under natural conditions obtain their food as they grow; and so, in the latter case, light must be taken into consideration. This will be done under the heading of Light.

The effect of temperature on the rate of photosynthesis is interesting in this connection. Brown and Heise have shown * that variations in temperature, such as occur at different elevations on Mount Maquiling, would apparently have comparatively little effect on the rate of photosynthesis. Kreusler has made an extensive study of the relation of temperature to the rate of photosynthesis. The writer has been unable to see copies of Kreusler's original publications and so has had to depend on the reviews for his results. According to Paladdin,† Kreusler found that at 15.8° the amount of carbon dioxide decomposed was 2.8, at 20.6° it was 2.6, and at 25° it was 2.9. In the present discussion, Matthaei's criticism of Kreusler's results to the effect that he measured the temperature of the air and not that of the leaves is of little or no importance. The results, as just quoted, would seem to show that, with such temperatures as occur on Mount Maquiling, the effect of variations in temperature would be negligible. According to Brown and Heise's interpretation of Matthaei's ‡ results, there would be little if any difference in the rate of photosynthesis of cherry laurel with the variations that occur on Maquiling. As the work of Kreusler and Matthaei is apparently the most careful and exact on the subject of the relation of temperature to rates of photosynthesis in land plants, we would appear to be justified in leaving out of consideration, in the following discussion, any possible effect of changes in temperature on the rate of photosyn-

* Brown, W. H., and Heise, G. W., The application of photochemical coefficients to the velocity of carbon dioxide assimilation, *Phil. Journ. Sci.*, *Sec. C* (1917), 12, 1–25.

† Livingston, B. E.–Paladdin, V. I., Plant Physiology. Philadelphia (1918), 35.

‡ Matthaei, G. L. C., Experimental researches on vegetable assimilation, III. On the effect of temperature on carbon dioxide assimilation, *Phil. Trans. Roy. Soc. London* (1905), B197, 47–105.

thesis, as any changes that might occur would probably be too small to have an appreciable effect on the vegetation.

A comparison of temperatures with rates of growth and sizes of trees on different mountains would indicate that, in the tropics under natural conditions, rates of growth or sizes of trees are not controlled entirely by the temperature.

At an elevation of about 1,500 meters on the Gedeh in Java there is a high forest in which Koorders * has measured a tree that was 49 meters in height. According to von Faber † the mean temperature in this forest for 1912 was 18°, and for 1913, 17.3°. These temperatures are very similar to the temperature obtaining at the top of Mount Maquiling. Brown and Yates ‡ have shown that the trees in the forest on the Gedeh at elevations of about 1,500 meters grow about as rapidly as those in the dipterocarp forest at low elevations in the Philippines. It would seem certain from this that the sizes of trees and rates of growth on tropical mountains may not correspond to the temperatures to which the plants are subjected.

On top of Mount Banahao, Luzon, Philippine Islands, at an altitude of 2,100 meters there is a forest composed of *Podocarpus imbricatus,* which reaches a height of about 14 meters, the average height of the canopy being about 12 meters. This forest is, therefore, taller than that occurring near the top of Mount Maquiling. The mean temperature, however, is 14.6° at the top of Mount Banahao and 17.8° at the top of Mount Maquiling.

The difference between the light intensity at an elevation of 450 meters and that at 1,050 meters on Mount Maquiling would apparently account for as great a difference in the rates of growth as would the temperature according to Lehenbauer's curve.

We may, therefore, conclude that, while variations in temperature at different elevations on Mount Maquiling probably have considerable influence in producing changes in rates of growth and in size of trees, such variations in temperature are not sufficient to account for the observed differences in the vegetation.

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* Koorders, S. H., Floristischer Ueberblick über die Blütenpflanzen des Urwaldes auf dem Vulkan Gede in West Java nebst einer systematischen Uebersicht der dort für botanische Untersuchungen von mir numerierten Waldbäume, *Engl. Bot. Jahrb.* (1914), **50**, Suppl. 278–303.

† Von Faber, D. C., Physiologische Fragmente aus einem tropischen Urwald, *Jahrb. Wiss. Bot.* (1915), **56**, 197–220.

‡ Brown, W. H., and Yates, H. S., The rate of growth of some trees on the Gedeh, Java, *Phil. Journ. Sci., Sec. C* (1917), **12**, 305–316.

In Table XC are given the averages of the weekly maximum temperatures in the tops of the trees at different elevations on Mount Maquiling. An examination of this table would indicate that, while the maximum temperatures in trees at elevations of 300 meters or more are comparatively close to the optima as calculated by Lehenbauer, those at the base are higher, the average of the weekly maxima being 38.2°. As, however, these maximum temperatures are maintained for only short periods, it is not to be expected that they would have much effect in retarding growth.

LIGHT

METHODS OF MEASUREMENT

No very satisfactory method of obtaining summations of light intensity for weekly periods has as yet been devised. The most practical instrument for the purpose is probably the Livingston radio-atmometer.*

The radio-atmometer is similar to the ordinary atmometer, except that the surface when wet is nearly black, whereas that of the ordinary form is white. After the readings have been reduced to Livingston's standard, the difference between the evaporation from the black cup and that from the white cup gives a fair measure of the effect of the heat rays of light in producing evaporation. This difference can, therefore, be used as a rough measure of light intensity.

In the operation of the radio-atmometer, when only a single black and a single white cup are used, there is a serious error due to the fact that both cups may show deviations from their coefficients of correction as obtained by standardization. In the use of an ordinary atmometer this error is not serious, for an error of 2 or 3 per cent in the readings of evaporation is certainly within the limits within which we can ordinarily apply the results. However, the error is greatly magnified when we use the difference between the rates of evaporation from the two cups, for then the total error of both (unless the errors are in the same direction) will either be added to or be subtracted from a very much smaller amount than the total evaporation from either cup. This error can be obviated to a great extent by the use of duplicate instruments and by averaging the rates for a considerable period. In the work on Mount Maquiling two or more instruments of both types were always used at each station. Owing to the possible seriousness of the above-mentioned error, the detailed results are not presented, although they do not indicate that the error is as great in practice as it might be in theory.

LIGHT INTENSITY AT DIFFERENT ELEVATIONS

Light intensity as measured by the difference in evaporation from a radio-atmometer and from an ordinary atmometer, from

* For a discussion of this instrument see Livingston, B. E., Atmometry and the porous cup atmometer, *Plant World* (1915), 18, 21.

October, 1912, to January, 1915, is presented in Table XCI in the form of average daily differences in cubic centimeters for corresponding four-week periods. The presentation of data in this form should certainly give sufficient averages to obviate any considerable error from the source just discussed. There is, however, another possible source of error in the readings on Mount Maquiling, which is not obviated by such averages. At the base of the mountain the cups always appeared dry and felt only slightly moist, whereas at the top of the mountain they had a very wet appearance, as though the outer surface of the cups were constantly covered with a film of moisture. Now, it seems possible that the effect of sunlight might be more pronounced on a very wet surface than on a drier one. This error is probably not serious, but its magnitude is uncertain.

TABLE XCI.—*Average daily light intensity for periods of four weeks from October, 1912, to January, 1915, in tops of dominant trees at different elevations on Mount Maquiling, as measured by the difference between the evaporation from a white and from a black Livingston atmometer.*

[Numbers give the difference in evaporation in cubic centimeters from a white and from a black Livingston atmometer.]

Four weeks ending—	Elevation in meters.				
	80.	300.	450.	740.	1,050.
January 31	5.5	4.8	4.1	2.9	2.6
February 28	5.5	5.0	4.1	3.6	3.1
March 28	7.9	7.0	5.2	5.1	3.7
April 25	9.0	7.9	5.4	4.6	3.0
May 23	7.1	6.9	6.9	4.1	2.6
June 20	7.7	6.3	6.5	5.0	3.0
July 18	7.2	5.9	4.6	4.3	2.4
August 15	5.3	5.1	4.9	3.8	3.0
September 12	4.9	5.0	4.5	3.2	2.1
October 10	6.6	7.2	6.2	5.3	3.6
November 7	5.9	6.2	5.2	4.3	3.0
December 5	5.5	5.3	4.5	3.4	2.5
January 2	5.3	4.7	4.3	2.8	2.0
Average	6.4	5.9	5.1	4.0	2.8

The results in Table XCI show that the yearly average of light intensity, as recorded by a radio-atmometer, decreases considerably as higher elevations are reached. Measured in terms of evaporation in cubic centimeters, the average light intensity at the base was 6.4; at 300 meters, 5.9; at 450 meters, 5.1; at 740 meters, 4; and at 1,050 meters, 2.8. It will be seen that the light intensity at the top of the mountain, as measured

in this manner, is only 44 per cent of that at the base or, in other words, that the light intensity at the base is 2.3 times as great as at the top.

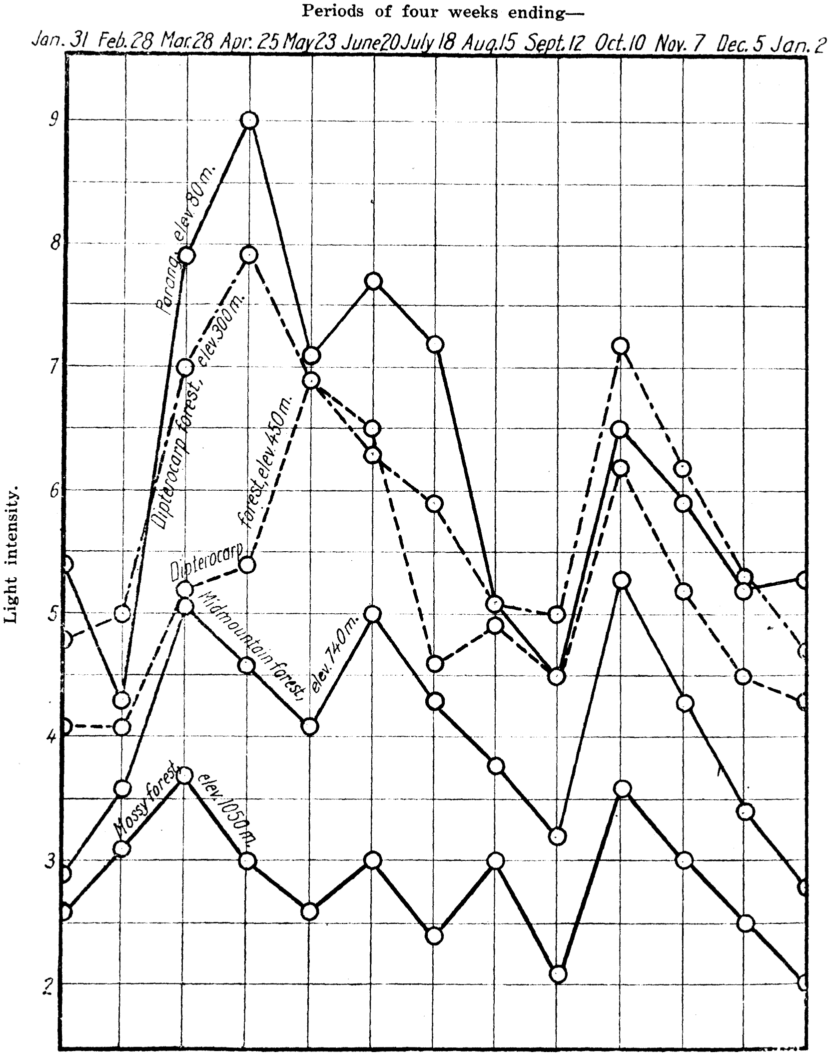

FIG. 11. Average daily light intensity in the top of dominant trees at different altitudes on Mount Maquiling.

The light intensity at different elevations is shown for four-week periods in fig. 11. At an elevation of 80 meters it will be noted that there are two maximum and minimum periods. The light intensity is low in February, rises and reaches a maximum during the period ending April 25, after which it

falls, reaching the lowest minimum during the period ending September 12. Following this there is another, though lower, maximum for the period ending October 10, and thereafter a steady fall until the period ending January 2.

In the region under discussion the sun is overhead during the last week in April, and it will be noticed that this is about the period of maximum insolation. The sun is again overhead in August, which is during the rainy or typhoon season, when the sky is overcast with clouds for a considerable portion of the time. In consequence, this period, instead of being one of high insolation, is one during which the average intensity of the light approaches the minimum.

The curves for the dipterocarp forest are similar in form to the curve for the parang; but at 740 meters, in the midmountain forest, there is not so marked a difference with the change of seasons. At the top of the mountain, in the mossy forest, the light intensity during the rainy season and at the end of the year is not much less than at other times. This change in the form of the curves, as higher elevations are reached, is probably due to the increased cloudiness at the top of the mountain. These curves indicate that the highest maximum for a four-week period in the mossy forest was 3.7, and in the parang, 9. It will thus be seen that for any considerable period, the light intensity at the top of the mountain is very much less than at the base.

RELATION OF LIGHT INTENSITY TO VEGETATION

In attempting to interpret the effect of light on vegetation we are met by the same difficulties that so often occur in ecological work in attempting to relate environment to vegetation; that is, a lack of knowledge of the relation of environmental factors to physiological processes. Many writers have supposed that the rate of photosynthesis is proportional to the light intensity until a certain maximum is reached, and that further increases in light have no effect. This maximum has been variously estimated at between one-quarter and full sunlight. However, Brown and Heise * have shown that the published literature affords no evidence of such a relation; but that, on the contrary, at least up to about full sunlight, there is a rise in the rate of photosynthesis for every increase in the intensity of the light, but that the augmentation in the rate of photosynthesis

* Brown, W. H., and Heise, G. W., The relation between light intensity and carbon dioxide assimilation, *Phil. Journ. Sci., Sec. C* (1917), 12, 85–95.

becomes progressively less and less with progressive increases in light intensity. Unfortunately, most of the work on the relationship of photosynthesis to light intensity has been done by the bubble-counting method on submerged plants. Kniep * has shown that the oxygen content of bubbles varies from 22 to 45 per cent, depending upon the intensity of the light. His paper makes it very clear that the number of bubbles given off by a plant is not necessarily proportional to the assimilation. It is, however, certain that for variations in light intensity up to one-quarter or one-half of full sunlight the effect of increased light on photosynthesis is very marked.

Despite the lack of information concerning the relation between light intensity and photosynthesis, it seems advisable to try to determine something of the effect of varying light intensities at different elevations upon the vegetation. An examination of Table XCI shows that for the four-week period ending April 25 there was an average light intensity of 9 for the two years at an elevation of 80 meters, and the individual tables make it fairly certain that the light intensity for a day may be about 13. It would appear, therefore, that the average daily light intensity for the entire year at 80 meters, 6.4, is probably not much more than half the maximum intensity for an entire day. It must also be remembered that during the morning and afternoon hours there are considerable periods when the sun is shining, but when the intensity of the light (even with a practically clear sky) is much less than full midday sunlight; moreover, that at any time only a part of a tree will receive full sunlight, while during considerable portions of a day a large part of the crown is in the shade. It would seem, therefore, that any considerable decrease in the average light intensity from that found at the base would result in a decreased rate of photosynthesis and consequently slower growth, and perhaps a smaller size of the vegetation. The highest average light intensity at the top of the mountain for any four-week period was 3.7, which is only 28 per cent of the probable highest value for a clear day at the base. As mentioned above, the average light intensity at the top of the mountain is only 44 per cent of that at the base. From these figures it would seem highly probable that the decreased light at the top of the mountain would account for a considerable diminution in the rate of photosynthesis and growth and, perhaps, for a smaller size in the trees.

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* Kniep, H., Ueber den Gasaustausch der Wasserpflanzen, *Jahrb. Wiss. Bot.* (1915), 56, 460–510.

It will be noted that the difference in intensity of light as measured by the radio-atmometer was much less between elevations of 80 and 450 meters than between 450 and 1,050 meters. It has also been shown that the variation in the sizes of the trees in the dipterocarp forest is comparatively slight, and it is not probable that the forest which formerly existed at an elevation of 80 meters was much taller than that now growing at slightly higher altitudes. The difference in light intensity between the two elevations in the dipterocarp forest is about as great as the difference in the size of the trees. However, the difference in light intensity between elevations of 450 and 1,050 meters is not nearly so great as the difference in the size of the vegetation. The light intensity as measured by a radio-atmometer is 1.8 times as great at 450 meters as at 1,050 meters, while the vegetation is at least three times as tall at the former altitude as at the latter. Moreover, the light intensity at 300 meters is 1.5 times as great as at 750 meters, while the difference in the rates of growth of the trees at these two elevations is very much greater. It would thus seem that the decrease in light intensity at higher elevations probably has a very important influence in retarding the rates of photosynthesis and probably of growth, but that the differences in light do not appear to be sufficient to account entirely for the slow rates of growth at 740 meters and at the top of the mountain or for the smaller sizes of the trees in these two situations.

The discussion of the effect of temperature and light seems to show that neither of these factors alone is sufficient to account for the differences in the rates of growth and the heights of vegetation at different altitudes. It will be interesting, therefore, to see whether the two together can account for such differences. Livingston and Livingston * have suggested a means of estimating the effect of temperature on growth in different localities. They assume that the rate of growth is unity at 40° F., and that it doubles for every rise of 10° C.; in other words, that the effect of temperature on growth follows the well-known Van Hoff principle: If t is taken as the normal daily mean temperature on the Fahrenheit scale, and if U is the corresponding temperature coefficient for growth, then, according to the above assumption,

$$U = \frac{2^{t} - 40}{18}.$$

* Livingston, B. E., and Livingston, G. J., Temperature coefficients in plant geography and climatology, *Bot. Gaz.* (1913), **56**, 349-375.

The indices obtained in this manner are called exponential indices. The time element is taken into account by adding together the efficiency indices for all the days of the frostless season. Livingston * has devised another series of indices based on Lehenbauer's work on the relation of temperature to the growth of maize seedlings; these are designated physiological indices.

In Table XCII are shown the average daily temperature indices, according to the exponential system, for four-week periods

TABLE XCII.—*Exponential temperature indices for different elevations on Mount Maquiling.*

[Numbers give average daily temperature indices.]

Four weeks ending—	Elevation in meters.				
	80.	300.	450.	740.	1,050.
January 31	3.8480	3.1748	2.9391	2.8284	2.2451
February 28	4.0000	3.2986	3.0545	2.8284	2.2451
March 28	4.8490	3.5629	3.5629	3.1748	2.4245
April 25	4.8490	3.8480	3.8480	3.2986	2.5198
May 23	5.0396	4.1572	4.1572	3.5629	2.7212
June 20	5.0396	4.1572	4.0000	3.7024	2.8284
July 18	4.6662	3.8480	3.8480	3.4283	2.8284
August 15	4.4902	3.7024	3.7024	3.2986	2.5198
September 12	4.6662	3.8480	3.5629	3.4283	2.5198
October 10	4.4902	3.7024	3.7024	3.4283	2.6192
November 7	4.3206	3.5629	3.4283	3.1748	2.5198
December 5	4.3206	3.5629	3.4283	3.0545	2.4245
January 2	4.1572	3.2986	3.2986	2.9391	2.3331
Average	4.5182	3.6711	3.5794	3.2421	2.5191

at different elevations on Mount Maquiling; and in Table XCIII, the average daily physiological indices. In order to take light into account the light intensity, as measured in cubic centimeters by the difference between the rate of evaporation from the white and from the radio-atmometers, has been multiplied by the average temperature indices for different elevations on Mount Maquiling. In the following discussion these products are, for convenience, called temperature-light indices. The results are given in Table XCIV, together with the heights of the vegetation at different altitudes.

At the top of the mountain the tallest trees are not more than 8 meters high, while at about 30 meters below the summit, in the plots where exact measurements were taken, the tallest

* Livingston, B. E., Physiological temperature indices for the study of plant growth in relation to climatic conditions. *Physiological Researches* (1916), 1, 399–420.

TABLE XCIII.—*Physiological temperature indices for different elevations on Mount Maquiling.*

[Numbers give average daily temperature indices.]

Four weeks ending—	Elevation in meters.				
	80.	300.	450.	740.	1,050.
January 31	79.111	54.778	46.000	38.000	21.556
February 28	79.111	63.444	54.778	38.000	21.556
March 28	101.222	71.111	71.111	54.778	26.000
April 25	101.222	79.111	79.111	63.444	31.333
May 23	108.444	86.556	86.556	71.111	38.000
June 20	108.444	86.556	86.556	71.111	46.000
July 18	101.222	79.111	79.111	63.444	38.000
August 15	94.000	79.111	71.111	63.444	31.333
September 12	101.222	79.111	71.111	63.444	31.333
October 10	94.000	71.111	71.111	63.444	31.333
November 7	94.000	71.111	63.444	54.778	31.333
December 5	94.000	71.111	63.444	54.778	26.000
January 2	86.556	63.444	63.444	46.000	26.000
Average	95.581	73.513	69.761	57.367	30.752

TABLE XCIV.—*Temperature-light indices as compared with the heights of trees at different elevations on Mount Maquiling.*

Altitude.	Exponential temperature-light index.	Physiological temperature-light index.	Exponential temperature-light index × 2.	Physiological temperature-light index ÷ 10.	Height of trees.
Meters.					*Meters.*
80	28.9165	611.7184	57.8330	61.1718	----------
300	21.6595	433.7267	43.3190	43.3727	38
450	18.2549	355.7811	36.5098	35.5781	36
740	12.9684	229.4680	25.9368	22.9468	22
1,050	7.0535	86.1056	14.1070	8.6106	8-14

trees are about 14 meters in height. It is not improbable that at the very summit the small size of the trees is due in part to rapid erosion, as the ground near the summit is very steep; however, many of the trees are fairly erect. As there is some doubt as to whether 8 or 14 meters should be taken as the height of the trees at the summit, both figures have been included in the table. The temperature-light indices are, of course, simply ratios. In order to have these of the same general magnitude as the heights of the vegetation, the exponential temperature-light indices have been multiplied by 2 and the results given in column 4, Table XCIV. Likewise, the physiological temperature-light indices have been divided by 10 and the results given in column 5, Table XCIV. If now we compare the results with

the heights of the trees, we find that the agreement is strikingly close, particularly at higher elevations. At the top of the mountain the figure obtained by the use of the exponential temperature-light indices is 14.1, and that by the physiological indices is 8.6; whereas the height of the trees, as before mentioned, can be taken as either 8 or 14 meters. At 740 meters, in the midmountain forest, the exponential indices gave the figure 25.9, and the physiological indices gave 22.9, whereas the height of the trees was 22 meters. At 450 meters the use of the exponential indices gave 36.5, and the physiological indices gave 35.6, while the trees were about 36 meters in height. At 300 meters the exponential indices gave 43.3, and the physiological indices gave 43.4, whereas the height of the trees was about 38 meters. At an elevation of 80 meters the forest has been removed, but we have no reason for believing that the trees were more than 40 or 45 meters in height. The use of the exponential temperature indices at this altitude gave 57.8, and the physiological indices gave 61.2. Both of these figures are, therefore, probably much higher than would be required by the height of the vegetation that formerly existed in this area. However, it should be remembered that at lower elevations the rate of evaporation is much greater than at higher altitudes, while, as will be shown later, the water content of the soil is lower. These two factors might very well account for a lower height of vegetation than could be produced by the temperature and light if other conditions were favorable. The figures derived from the temperature-light indices do, however, agree almost exactly with the height of trees at this elevation in regions where there is a more even distribution of rainfall and no distinct dry season. In such favorable situations trees reach a height of 60 meters. The figures obtained from the temperature-light indices at an elevation of 300 meters are also somewhat too high, but this discrepancy may again be due to moisture conditions, as the effect of the dry season on the vegetation at this altitude is marked. *Parashorea* shows its slowest rate of growth during the dry season, and the canopy of the forest is much less dense during this season than at other times.

It should be remembered, moreover, that photosynthesis is not proportional to light intensity and that, as greater light intensities are reached, the rate of photosynthesis increases less and less with the augmentation of light intensity. This may explain in part the lack of agreement between the temperature-light indices and the heights of the trees at lower elevations.

Leitch * has made a very careful study of the influence of temperature on the rates of growth of roots of *Pisum sativum.* For the purpose of showing how the figures for growth at different temperatures as obtained by Leitch, and multiplied by the light intensity as measured at different elevations on Mount Maquiling, correspond to the heights of the vegetation and the rates of growth, her figures have been treated in a manner similar to Livingston's treatment of Lehenbauer's results. Although Livingston's temperature indices were calculated for four-week periods on Mount Maquiling, the results obtained are very much like those produced by simply using the mean temperatures for the entire year. For this reason, in dealing with Leitch's results, the growth figures corresponding to the different annual mean temperatures on Mount Maquiling have been calculated from her curve showing the relation of temperature to growth in millimeters for twenty-two and one-half hours. These figures are shown in Table XCV. In the same table are also given the light intensities at different elevations on Mount Maquiling and the products of the figures for light intensity by the figures for growth. In the following discussion these products will be called *Pisum* temperature-light indices. As these indices can only be regarded as ratios they have been divided by 3.2, in order to have them of the same general magnitude as the heights of the vegetation. The results and the heights of the vegetation at different elevations on Mount Maquiling are also recorded in Table XCV. An examination of Table XCV shows that the ratios obtained by the use of Leitch's measurements are, like those obtained from Livingston's temperature indices, very similar to the heights of the trees.

TABLE XCV.—*Pisum temperature-light indices as compared with the heights of trees at different elevations on Mount Maquiling.*

Altitude.	Growth figures corresponding to temperature.	Light intensity.	Temperature-light index.	Temperature-light index ÷3.2	Height of vegetation.
Meters.					*Meters.*
80	24.5	6.4	156.8	49.0	----------
300	22.5	5.9	132.8	41.5	38
450	22.0	5.1	112.2	35.1	36
740	20.5	4.0	82.0	25.6	22
1,050	16.5	2.8	46.2	14.4	8-14

* Leitch, I., Some experiments on the influence of temperature on the rate of growth in Pisum sativum, *Ann. Bot.* (1916), 30, 25–46.

It would probably be better to compare the volume, rather than the heights of the vegetation, with the temperature-light indices, but this would be much more difficult. However, a comparison of the volume of the dipterocarp and the midmountain forests, as previously given, indicates that the volume and the heights of the forests are roughly proportionate.

TABLE XCVI.—*Ratios of temperature-light indices and rates of growth of Parashorea and Astronia.*

Altitude.	Exponential temperature-light index.	Physiological temperature-light index.	*Pisum* temperature-light index.	Rate of growth.
Meters.				
300	1.7	1.9	1.6	2
740	1.0	1.0	1.0	1

It is interesting to compare the ratios of temperature-light indices not only with the heights of the vegetation, but also with the rates of growth of trees at different elevations. Such comparison is made in Table XCVI. In this table the average rates of growth of *Parashorea malaanonan,* for diameter classes between 20 and 50 centimeters, at an elevation of 300 meters, have been divided by the average rates of growth of *Astronia pulchra,* of similar sizes, at an elevation of 740 meters. These classes were selected as the trees in them were in the dominant story in both cases. The ratio as thus calculated is 2 to 1, using the rate of *Astronia* as unity. In order to have the ratios of the temperature-light indices comparable with the ratios for growth, the temperature-light indices for an elevation of 740 meters have been divided into those for 300 meters. The temperature-light index obtained by the use of the Livingston physiological temperature indices at 740 meters is to that at 300 meters as 1 to 1.9. This result is as close to the ratio for rates of growth at these two elevations as could be expected from the use of two different species. The ratio obtained with Leitch's figures is 1 to 1.6. This ratio is not so similar to that for growth as is the ratio of the physiological indices, but when we consider that Leitch was working with the roots of a small herbaceous plant, the difference is not surprising. In Table XCVII similar comparisons are made between the rates of growth of second-growth trees at the base of the mountain and a second-growth tree, *Homalanthus alpinus,* at an altitude of 1,050 meters. In

the discussion of the growth of parang species these trees are divided into two classes; namely, those which do not reach a diameter of 20 centimeters and those which attain a diameter greater than 20 centimeters. In Table XCVII the ratios between the rates of growth of *Homalanthus alpinus* and both of these classes are given, for the average of the diameter classes of 5 to 10 centimeters and of 10 to 15 centimeters. In this table are also shown the ratios obtained by dividing the temperature-light indices for an elevation of 80 meters by those at an elevation of 1,050 meters. The smaller trees at the base of the mountain showed an average rate of growth 4.4 times that of *Homalanthus alpinus,* and the larger trees a rate which was 6.3 times as great as that of *Homalanthus.* The physiological temperature-light indices gave a ratio of 7.1 to 1, and the *Pisum* indices gave 3.4 to 1. The ratios for the trees of both sizes are intermediate between these two ratios. The physiological temperature-light indices gave a ratio which was greater than that for the large trees and *Homalanthus alpinus,* and the *Pisum* indices showed a lower ratio than that for the smaller trees and *Homalanthus alpinus.* The ratio for exponential temperature-light indices is fairly close to that for *Homalanthus alpinus* and the smaller trees. These results are probably about as close as could be expected under the circumstances. The ratios of growth to temperature-light indices are not so close as those for these indices and the heights of the vegetation, but they do show the same general sort of agreement.

TABLE XCVII.—*Ratios of temperature-light indices and rates of growth of second-growth trees.*

Altitude.	Exponential temperature-light index.	Physiological temperature-light index.	*Pisum* temperature-light index.	Rate of growth.
Meters.				
80	4.1	7.1	3.4	[a]6.3 [b]4.4
1,000	1.0	1.0	1.0	1.0

[a] Trees which attain diameters greater than 20 centimeters.
[b] Trees which do not reach a diameter of 20 centimeters.

The agreement between ratios for the heights of the vegetation and the ratios obtained by multiplying the figures for light intensity and temperature indices together would appear to be too close to be accidental; and, if this treatment is justified, the combination of temperature and light intensity would seem

to be sufficient to account for the differences in the rates of growth and the heights of the trees at different elevations in the virgin forest. Such a relation, while it may seem probable, needs the further corroboration of other similar cases or of exact laboratory experimentation to show that a combination of light and temperature can produce similar results. Of course, even supposing that light and temperature are responsible for the rates of growth and sizes of the trees at different elevations, such results could not be expected to be duplicated in all cases, as other factors must be taken into account. A further discussion of these points will be given in connection with evaporation.

RAINFALL

The recording of the rainfall at the base of Mount Maquiling was begun by Dr. F. W. Foxworthy on August 16, 1911. His records between this date and October, 1912, when the writer began to take them, are included in the records for the base of the mountain. Most of the records were, however, begun in October, 1912, and were taken by means of a rain gauge of the same type as that used by the United States Weather Service. At an elevation of 80 meters the gauges were read daily at about 6 o'clock in the morning, and at higher elevations they were read weekly.

At an elevation of 300 meters one rain gauge was placed in the top of a dominant *Parashorea*, and another in a small clearing. The records from these two gauges varied somewhat during different weeks. Frequently when the wind velocity was high, the reading from the gauge in the top of the tree was higher than from the one in the clearing; on the other hand, when the rain was not accompanied by high wind velocity, the gauge in the clearing sometimes gave a slightly higher reading than the one in the top of the tree. This was probably due to the fact that the rate of evaporation was greater in the top of the tree than in the clearing. In the following tables the highest of the two readings is used, as it is believed that this method gives the most accurate measurement of the actual rainfall.

The figures recorded in this publication, for rainfall at 300 meters' elevation, are slightly different from those previously given by Brown and Matthews. The difference is due to the fact that the results here presented were obtained from two gauges, as just described; whereas in the former paper readings from only one gauge were given.

At 450 meters' elevation a gauge was placed in the center of a 0.25-hectare clearing; and at 740 meters in the top of a dominant tree. At the summit of the east peak the gauge was in a clearing that was sufficiently large to prevent the trees from interfering with the entrance of water into the gauge.

When a gauge is read weekly the readings are, of course, subject to an error due to evaporation; but at the higher elevations, where rates of evaporation are low, this error is probably inconsiderable. However, in order to find out what this error might be under extreme conditions, one gauge was read weekly

for a considerable period at an elevation of 80 meters, and it was found that the results shown by the gauge read weekly varied only very slightly from those recorded by the one read daily; so that we may conclude that errors in the total amount of rainfall, due to evaporation, are almost negligible at all elevations at which the readings were taken weekly.

RAINFALL AT THE BASE OF THE MOUNTAIN

The daily readings of rainfall at an elevation of 80 meters are given in Table XCVIII. The results are plotted by months for the different years in fig. 12. An examination of this figure shows not only that there is a very marked difference between the dry and the rainy seasons, but also that there is considerable irregularity in the seasons during different years.

TABLE XCVIII.—*Rainfall in centimeters at the base of Mount Maquiling.*

AUGUST 16 TO DECEMBER 31, 1911.

Day.	August.	September.	October.	November.	December.
1					
2		0.051			
3			0.127	0.076	0.025
4					0.051
5					0.024
6					
7			0.787		
8		0.229			
9					
10		0.203	0.051		0.178
11					
12		0.127			
13			0.813		
14					
15					
16			0.508	0.203	0.178
17					4.013
18	2.464	1.016	0.025	0.559	
19	2.845	0.254	0.381	0.635	
20	1.651	2.413	0.025	0.051	
21	0.533	0.508	0.254	0.178	0.432
22		3.127		0.127	0.025
23	0.025		0.025		0.025
24		0.152	0.051		0.076
25	2.743		0.203		0.381
26	0.102				
27					
28		1.295			0.076
29		2.591			0.051
30		0.838			
31	0.152				
Total	10.515	12.804	3.250	1.829	5.535

TABLE XCVIII.—*Rainfall in centimeters at the base of Mount Maquiling*—Continued.

YEAR 1912.

Day.	January.	February.	March. [a]	April.	May.	June.	July.	August.	September.	October.	November.	December.
1		0.10				2.06		0.62	11.68	1.03	0.01	
2	0.10							1.19	0.66			
3		0.89				0.08			1.03		0.33	
4	0.33	0.71					2.17			0.21		
5	1.80	1.04					0.32			4.80	0.01	
6	0.28	0.79						0.86			0.41	
7	0.03	0.30			1.75	0.33		0.45	1.11	4.22	3.95	
8	0.03	0.08			0.25		0.21		2.75	1.61	0.06	
9					2.29	1.80	1.68	0.21	2.18	0.70	1.44	
10										0.08	0.49	1.14
11	0.41							5.04		2.09		
12	0.08							2.05	0.08	2.47	0.04	0.49
13	0.13							0.90	0.41	0.06		0.29
14				0.33		0.69	3.28		2.85	0.29		0.04
15						0.23	0.45	2.75		1.80	0.49	0.03
16							0.41			2.93	0.20	
17		0.05				0.03	1.02		0.18	9.31	0.70	0.16
18		0.07					4.59	2.62	0.55	3.07	0.06	0.08
19		0.10					3.28			0.25		
20								1.27	3.44	0.39		
21		0.25			2.64		2.87	2.66			2.87	
22		0.08				0.18	0.25			1.61		
23										0.21		
24						0.28			1.93	0.21		
25					3.28		2.01	6.97		0.05	2.17	0.53
26								2.99	0.41			3.81
27	0.25				0.15	0.36		0.29	0.08			0.04
28						0.15	2.21	0.58	0.49			0.02
29	0.30					0.15	2.41	2.25	2.01		7.52	
30	0.08					1.78	0.82			0.01	0.62	0.57
31	0.08				5.08		1.52	12.30		2.69		0.37
Total	3.90	4.46	1.30	0.33	15.44	8.12	29.50	46.00	31.84	40.09	21.37	7.07

YEAR 1913.

Day.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	1.10	0.08	0.33				1.97	0.42	0.43		0.14	0.04
2	8.42		0.12				0.16	0.15			0.03	
3								0.19	1.12	2.31		
4					1.44		0.34	0.48	0.85		0.69	
5	0.04				0.37		0.36	3.46	0.74		0.94	0.39
6	0.04		0.16		0.41	0.21		0.11	0.18	1.46	0.20	0.22
7	0.19				1.72		2.08	0.83			0.27	0.52
8			1.12			0.33	1.06	0.24		0.48	0.26	0.02

[a] Daily record lost. Doctor Foxworthy's record book shows five days with showers.

TABLE XCVIII.—*Rainfall in centimeters at the base of Mount Maquiling*—Continued.

YEAR 1913—Continued.

Day.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
9	------	------	------	------	0.29	------	0.03	0.19	0.10	------	1.57	0.28
10	0.08	------	------	------	0.12	------	0.85	------	3.22	0.11	0.81	0.13
11	------	------	------	------	------	------	0.12	0.07	16.90	------	0.29	1.07
12	------	0.11	------	------	------	------	3.63	1.91	1.19	0.10	0.09	0.01
13	------	------	------	------	0.21	------	0.15	0.13	------	2.05	0.09	------
14	------	------	------	0.45	------	------	0.31	0.23	------	6.80	------	0.30
15	------	------	------	1.29	------	------	3.95	0.28	------	1.27	------	1.01
16	------	------	------	0.45	------	------	2.78	1.51	------	------	0.15	0.40
17	------	------	------	2.46	0.39	0.41	0.51	8.10	0.87	1.44	0.05	------
18	------	0.16	------	------	2.58	0.06	1.06	0.84	------	------	------	0.46
19	------	------	------	0.12	------	0.05	1.31	0.06	1.41	------	0.19	2.11
20	------	------	------	0.37	------	0.01	1.04	0.08	0.28	------	1.86	2.92
21	------	0.66	------	0.12	2.34	1.68	0.36	0.15	------	------	0.18	0.17
22	------	------	------	------	------	------	2.85	0.36	------	------	0.12	0.07
23	------	------	------	------	------	0.04	0.58	0.05	0.03	------	0.56	------
24	1.56	------	------	------	------	1.03	0.10	0.55	0.67	------	------	0.07
25	0.25	------	------	------	------	------	0.59	0.07	0.85	------	0.13	------
26	0.45	------	------	------	0.62	------	0.26	0.85	0.49	------	------	0.13
27	0.07	------	------	------	------	1.58	------	1.46	------	------	------	------
28	------	0.78	------	0.07	0.06	0.04	2.55	0.10	------	------	1.25	------
29	0.04	------	------	------	------	1.85	8.70	0.30	------	------	0.02	0.29
30	0.08	------	------	------	0.29	------	4.35	0.14	0.12	------	0.24	0.26
31	0.25	------	------	------	------	------	0.72	------	------	0.10	------	0.01
Total	12.57	1.79	1.73	5.33	10.84	7.29	42.77	23.31	29.45	16.12	10.13	10.88

YEAR 1914.

Day.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	------	------	------	------	------	0.31	0.01	------	4.52	------	0.04	0.19
2	------	------	------	------	------	2.17	0.35	------	14.00	------	0.15	0.31
3	0.15	------	------	------	------	7.90	0.13	------	5.80	------	------	0.39
4	0.39	------	------	------	------	3.46	0.29	------	9.50	0.01	------	0.69
5	------	0.32	------	------	------	0.14	2.97	------	9.70	0.58	------	0.16
6	------	------	------	------	------	------	0.17	0.42	2.12	------	------	0.26
7	------	------	------	------	------	------	1.70	0.19	0.42	0.91	------	0.14
8	0.19	------	0.02	------	------	------	2.33	0.18	3.33	0.73	0.23	0.08
9	0.24	------	------	0.58	------	0.28	0.12	0.91	8.80	trace.	0.03	0.55
10	------	------	------	0.71	------	------	------	0.80	2.48	0.26	------	0.71
11	------	0.04	------	------	0.83	------	0.01	1.36	0.02	------	0.33	0.06
12	------	------	------	------	0.77	0.41	------	0.44	0.10	------	0.11	0.19
13	------	0.16	------	------	------	0.57	------	0.73	1.37	------	------	1.06
14	0.04	0.14	------	4.93	------	0.29	------	2.50	0.44	------	------	trace.
15	0.03	0.05	------	0.54	------	------	------	0.03	0.79	------	------	0.01
16	------	------	0.24	------	------	0.59	0.51	------	0.01	------	0.07	0.03

TABLE XCVIII.—*Rainfall in centimeters at the base of Mount Maquiling*—Continued.

YEAR 1914—Continued.

Day.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
17	------	------	0.06	------	------	------	0.87	0.03	0.83	0.04	0.02	0.03
18	------	------	0.01	------	------	0.03	1.06	0.55	0.05	0.97	------	------
19	------	------	------	------	0.03	5.54	0.29	------	------	0.46	------	------
20	------	------	------	------	0.31	7.60	1.02	2.56	------	0.09	------	0.05
21	------	------	------	0.43	3.44	0.56	0.56	0.15	------	------	------	0.06
22	------	------	------	------	1.31	0.80	0.09	3.27	0.72	0.02	------	trace.
23	0.41	------	------	0.67	------	1.06	0.26	2.04	0.02	0.15	------	------
24	0.21	------	------	------	------	0.11	0.61	------	------	trace	trace	------
25	0.03	------	------	------	------	0.03	0.66	------	------	0.11	------	0.64
26	------	------	------	0.23	------	0.03	0.67	------	1.44	0.86	------	0.01
27	------	0.49	0.07	0.24	0.02	------	0.05	------	2.48	------	0.75	trace.
28	------	------	------	------	------	------	------	0.31	------	------	5.21	trace.
29	------	------	------	------	0.06	0.70	------	0.93	0.54	0.78	0.11	------
30	------	------	------	------	0.68	0.52	------	0.40	0.39	------	0.32	0.03
31	------	------	------	------	0.30	------	------	0.54	------	------	------	0.19
Total	1.69	1.20	0.40	8.33	7.75	33.10	14.73	18.34	69.87	5.97	7.37	5.84

RAINFALL AT DIFFERENT ELEVATIONS

Rainfall was measured at the five stations at which temperature-recording instruments were placed; that is, at elevations of 80, 300, 450, 740, and 1,050 meters, respectively. A rain gauge was also placed in an open plot on the opposite slope of the east peak at an elevation of about 1,000 meters.

The weekly readings of rainfall at the different elevations are given in Table XCIX, and these are summarized for corresponding four-week periods for the individual years in Table C, and for the entire period in Table CI. The rainfall for the different four-week periods for 1914 are plotted in fig. 13.

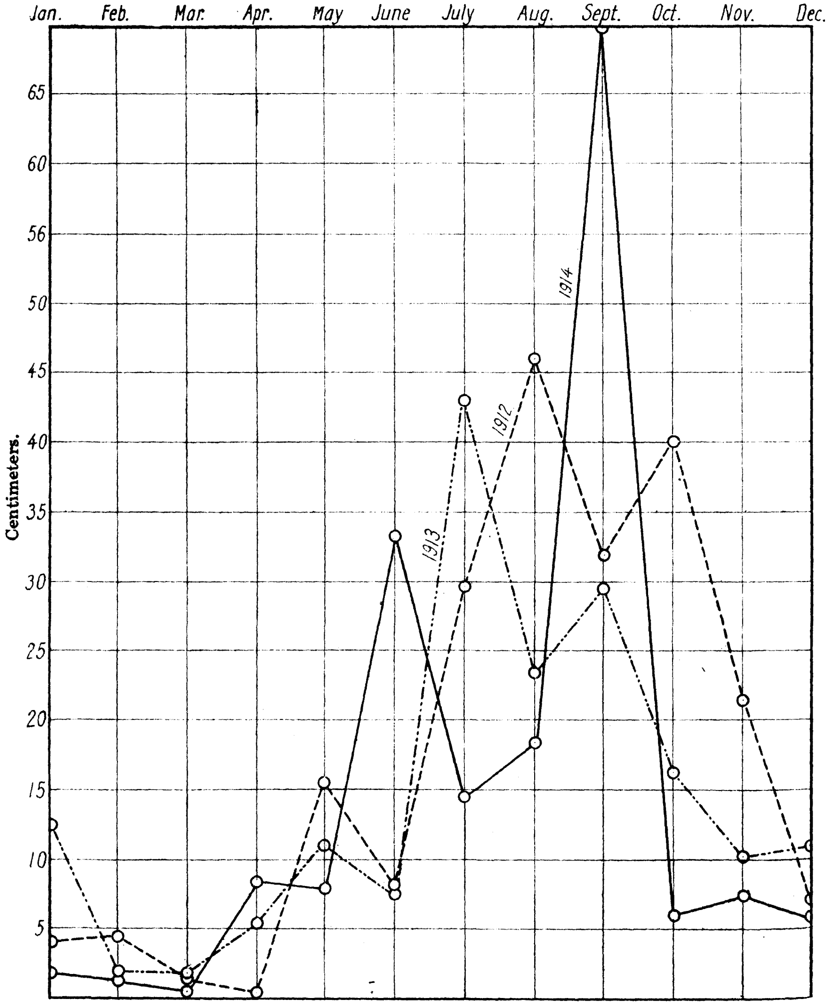

FIG. 12. Monthly rainfall at the base of Mount Maquiling; altitude, 80 meters.

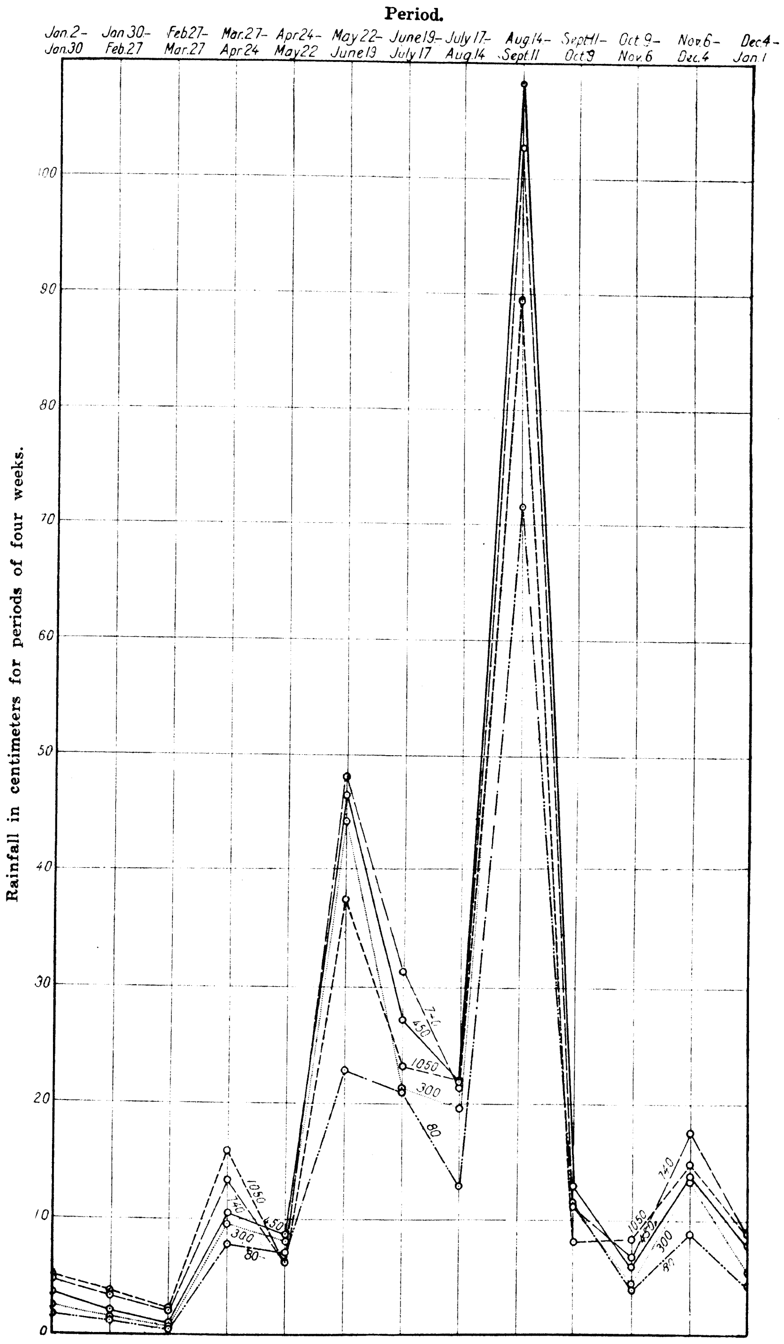

FIG. 13. Rainfall at different altitudes on Mount Maquiling.

TABLE XCIX.—*Rainfall for weekly periods in the open at different elevations on Mount Maquiling.*

[Numbers give rainfall in centimeters.]

Week ending—	Altitude in meters.					
	80.	300.	450.	740.	1,050.	1,000.
1912.						
October 11	13.50	4.20			21.30	
October 18	19.93	17.80			30.40	
October 25	2.72	3.29			4.69	
November 1	2.71	2.48			2.40	
November 8	4.76	6.30		9.20	8.30	
November 15	2.46	1.57		1.71	2.22	
November 22	3.83	4.01		6.33	6.04	
November 29	9.69	12.02		18.80	14.50	
December 6	0.62	0.69		0.00	0.58	
December 13	1.92	2.32		4.06	5.08	
December 20	0.31	0.51		0.84	1.27	
December 27	3.88	4.20		6.55	6.30	
1913.						
January 3	10.48	9.70		8.90	8.20	
January 10	0.35	1.84		3.70	3.95	
January 17	0.00	0.28		1.10	1.20	
January 24	1.56	1.80		3.90	5.10	
January 31	1.14	1.75		4.05	5.00	
February 7	0.08	0.59		1.13	1.39	
February 14	0.11	0.25		0.50	0.92	
February 21	0.82	1.41		0.69	1.00	
February 28	0.78	1.68		2.74	3.42	
March 7	0.61	1.85		2.47	2.75	
March 14	1.12	0.02		0.05	0.05	
March 21	0.00	0.00		0.00	0.15	
March 28	0.00	0.00		0.05	0.18	
April 4	0.00	0.00		0.06	0.22	
April 11	0.00	0.08		0.19	0.00	
April 18	4.65	0.37		0.51	0.70	
April 25	0.61	0.60		1.00	1.55	
May 2	0.07	0.05		0.55	1.77	
May 9	4.23	6.10		9.20	6.00	
May 16	0.33	1.54		2.20	2.25	
May 23	5.31	3.42		4.62	4.34	
May 30	0.97	3.90		1.94	2.82	
June 6	0.21	0.46		0.11	0.12	
June 13	0.33	0.74		0.07	0.80	
June 20	0.53	4.31		5.10	2.94	3.11
June 27	4.33	2.75		1.88	1.09	1.13
July 4	4.36	6.90	7.01	7.20	3.81	6.42
July 11	4.50	2.72	4.81	4.67	3.57	4.05
July 18	12.39	14.50	14.00	19.50	14.00	13.10
July 25	6.83	7.70	11.50	13.50	7.40	5.30
August 1	17.00	21.50	29.04	30.55	16.10	12.56
August 8	5.46	4.92	7.40	7.10	6.40	5.50
August 15	2.81	1.41	1.31	12.10	11.30	9.40
August 22	11.10	13.10	13.70	4.75	3.88	3.98

TABLE XCIX.—*Rainfall for weekly periods in the open at different elevations on Mount Maquiling*—Continued.

Week ending—	Altitude in meters.					
	80.	300.	450.	740.	1,050.	1,000.
1913.						
August 29	3.38	6.50	1.19	11.70	6.70	4.00
September 5	3.28	4.35	7.50	7.60	5.70	4.74
September 12	21.59	23.60	29.00	35.40	23.90	13.10
September 19	2.28	11.60	14.00	2.02	1.54	1.65
September 26	2.32	2.47	2.71	2.57	3.03	3.76
October 3	2.43	3.12	2.50	2.41	0.25	2.31
October 10	2.05	1.42	1.65	1.87	2.14	2.24
October 17	11.66	15.60	20.90	21.50	12.90	7.50
October 24	0.00	0.39	0.38	0.89	1.02	0.86
October 31	0.10	0.24	0.27	0.32	0.36	0.32
November 7	2.27	1.31	1.62	3.65	4.21	4.51
November 14	3.11	3.21	3.61	2.32	2.83	3.34
November 21	2.43	2.57	3.31	4.67	4.87	6.70
November 28	2.06	2.25	2.48	1.59	1.24	2.36
December 5	0.69	0.85	1.21	1.46	1.33	1.99
December 12	2.25	2.73	3.22	3.43	3.57	4.44
December 19	4.28	4.69	6.10	12.10	8.50	12.50
December 26	3.36	3.74	4.24	1.17	1.05	1.45
1914.						
January 2	0.56	0.99	1.44	2.99	3.84	4.77
January 9	0.97	1.32	1.82	1.97	2.24	2.86
January 16	0.07	0.24	0.46	1.07	1.26	1.55
January 23	0.41	0.75	1.12	1.53	1.48	1.86
January 30	0.24	0.16	0.19	0.18	0.15	0.19
February 6	0.32	0.32	0.42	0.52	0.64	0.81
February 13	0.20	0.36	0.68	1.71	2.13	2.86
February 20	0.19	0.21	0.25	0.19	0.08	0.16
February 27	0.49	0.61	0.77	0.93	0.96	1.13
March 6	0.00	0.13	0.26	0.62	0.84	0.96
March 13	0.02	0.00	0.00	0.19	0.14	0.11
March 20	0.31	0.43	0.60	1.13	1.08	1.33
March 27	0.07	0.11	0.16	0.19	0.23	0.26
April 3	0.00	0.00	0.00	0.09	0.14	0.11
April 10	1.29	1.25	0.96	2.52	2.37	2.86
April 17	5.47	6.60	7.60	8.50	10.80	10.60
April 24	1.10	1.66	1.94	2.26	2.57	3.18
May 1	0.47	0.17	0.00	0.06	0.02	0.05
May 8	0.00	0.00	0.00	0.00	0.00	0.11
May 15	1.60	1.93	2.54	1.21	2.18	1.98
May 22	5.09	5.90	6.10	4.96	4.06	4.12
May 29	0.08	0.27	0.26	1.41	1.85	1.47
June 5	14.96	20.60	22.80	26.10	15.60	9.10
June 12	0.69	0.46	0.35	0.26	0.21	0.27
June 19	7.02	22.90	23.10	20.30	19.90	17.80
June 26	10.19	3.25	3.21	3.26	2.63	3.89

TABLE XCIX.—*Rainfall for weekly periods in the open at different elevations on Mount Maquiling*—Continued.

Week ending—	Altitude in meters.					
	80.	300.	450.	740.	1,050.	1,000.
1914.						
July 3	1.71	2.75	3.73	5.08	6.20	5.09
July 10	7.58	13.60	16.80	18.50	9.70	6.70
July 17	1.39	1.63	3.35	4.30	4.60	4.05
July 24	3.89	8.30	7.50	5.70	8.90	7.30
July 31	1.38	1.41	1.61	2.22	2.10	1.75
August 7	0.61	1.53	1.89	2.20	2.38	2.36
August 14	6.92	8.20	10.80	11.10	8.60	3.97
August 21	3.32	1.03	1.36	11.60	10.60	12.10
August 28	5.62	10.00	11.40	2.46	1.77	1.50
September 4	35.69	47.50	55.60	60.40	52.60	44.10
September 11	26.87	30.80	39.90	28.20	24.50	17.20
September 18	3.59	3.74	3.53	1.73	1.11	0.85
September 25	0.74	0.72	1.21	3.25	2.66	2.99
October 2	4.85	4.17	5.40	4.42	2.31	4.00
October 9	2.24	2.46	2.68	1.79	1.99	2.24
October 16	0.26	0.26	0.04	0.87	1.68	1.67
October 23	1.73	2.38	2.61	2.23	1.81	2.26
October 30	1.76	1.17	2.76	3.23	3.82	4.79
November 6	0.19	0.63	0.49	0.38	0.95	1.19
November 13	0.70	1.79	2.33	2.77	2.53	3.19
November 20	0.09	0.33	0.21	0.35	0.43	0.54
November 27	0.76	0.92	0.97	10.40	8.60	9.80
December 4	7.22	10.20	10.20	3.91	3.21	3.97
December 11	1.96	2.11	3.19	3.89	4.35	4.89
December 18	1.33	1.99	2.94	3.01	2.56	3.17
December 25	0.76	0.81	1.02	1.08	0.94	1.46
1915.						
January 1	0.25	0.51	0.63	0.81	0.99	1.14

TABLE C.—*Total rainfall for periods of four weeks in the open at different elevations on Mount Maquiling.*

[Rainfall is given in centimeters.]

Four weeks ending—	Elevation in meters.					
	80.	300.	450.	740.	1,050.	1,000.
1912.						
November 8	30.12	29.87	----------	----------	45.79	----------
December 6	16.60	18.29	----------	26.84	23.34	----------
1913.						
January 3	16.59	16.73	----------	20.35	20.85	----------
Total	63.31	64.89	----------	47.19	89.98	----------
1913.						
January 31	3.05	5.67	----------	12.75	15.25	----------
February 28	1.79	3.93	----------	5.06	6.73	----------
March 28	1.73	1.87	----------	2.57	3.13	----------
April 25	5.26	1.05	----------	1.76	2.47	----------
May 23	9.94	11.11	----------	16.57	14.36	----------
June 20	2.04	9.41	----------	7.22	6.68	----------
July 18	25.58	26.87	----------	33.25	22.47	24.70
August 15	32.10	35.53	49.25	63.25	41.20	32.75
September 12	39.35	47.55	51.39	59.45	40.18	25.77
October 10	9.08	18.61	20.86	8.87	6.96	9.96
November 7	14.03	17.54	23.17	26.36	18.49	13.19
December 5	8.29	8.88	10.61	10.04	10.27	14.39
1914.						
January 2	10.45	12.15	15.00	19.69	16.96	23.16
Total	162.69	200.17	170.28	266.84	205.15	143.92
1914.						
January 30	1.69	2.47	3.59	4.75	5.13	6.46
February 27	1.20	1.50	2.12	3.35	3.81	4.96
March 27	0.40	0.67	1.02	2.13	2.29	2.66
April 24	7.86	9.51	10.50	13.37	15.88	16.75
May 22	7.16	8.00	8.64	6.23	6.26	6.26
June 19	22.75	44.23	46.51	48.07	37.56	28.64
July 17	20.87	21.23	27.09	31.14	23.13	19.73
August 14	12.80	19.44	21.80	21.22	21.98	15.38
September 11	71.50	89.33	108.26	102.66	89.47	74.90
October 9	11.42	11.09	12.82	11.19	8.07	10.08
November 6	3.94	4.44	5.90	6.71	8.26	9.91
December 4	8.77	13.24	13.71	17.43	14.77	17.50
1915.						
January 1	4.30	5.42	7.78	8.79	8.84	10.66
Total	174.66	230.57	269.74	277.04	245.45	223.89

TABLE CI.—*Average rainfall for periods of four weeks from October, 1912, to January, 1915, in the open at different elevations on Mount Maquiling.*

[Rainfall is given in centimeters.]

Four weeks ending—	Elevation in meters.					
	80.	300.	450.	740.	1,050.	1,000.
January 31	2.37	4.07	3.59	8.75	10.19	6.46
February 28	1.60	2.72	2.12	4.21	5.27	4.96
March 28	1.07	1.27	1.02	2.35	2.71	2.66
April 25	6.56	5.28	10.50	7.57	9.18	16.75
May 23	8.55	9.56	8.64	11.40	10.31	6.26
June 20	12.40	26.82	46.51	27.65	22.12	28.64
July 18	23.23	24.05	27.09	32.20	22.80	22.22
August 15	22.45	27.49	35.53	42.24	31.59	24.07
September 12	55.43	68.44	79.83	81.06	64.83	50.34
October 10	10.25	14.85	16.84	10.03	7.52	10.02
November 7	16.03	17.28	14.54	16.54	24.18	11.55
December 5	11.22	13.47	12.16	18.10	16.13	15.95
January 2	10.45	11.43	11.39	16.28	15.55	16.91
Total	181.61	226.73	269.76	278.38	242.38	216.79

The average rainfall at the base was 182 centimeters. This approaches the lower limit given by Schimper * for a rain forest. The amount of rainfall increases as higher elevations are reached, up to 740 meters. At 300 meters the average annual rainfall was 227 centimeters; at 450 meters, 270 centimeters; and at 740 meters, 278 centimeters. As might have been expected, the rainfall was less at the top of the mountain than at an elevation of 740 meters. At the top of the mountain, or 1,050 meters' elevation, the average annual rainfall was 242 centimeters, which amount is intermediate between that for elevations of 300 and of 450 meters. It will thus be seen that the rainfall in the mossy forest is about the same in amount as in the dipterocarp forest and is less than in the upper part of the dipterocarp forest; and that the midmountain forest apparently received more rain than either the dipterocarp or the mossy forest. The seasonal distribution of rain is approximately the same at all elevations, as may be seen by referring to fig. 13, in which are plotted the four-weekly rates for the year 1914 at the different elevations. This figure shows very clearly that the seasonal variations in rainfall are very similar at all elevations, and that in every case the distinction between the rainy season and the dry season is very marked.

* Schimper, A. F. W., Plant Geography upon a Physiological Basis. English translation by W. R. Fisher, Oxford (1903).

RELATION OF RAINFALL TO VEGETATION

A consideration of Table CI and fig. 13 would indicate that the rainfall, as a direct factor, is not responsible for the progressive changes which we find in the vegetation between lower and higher altitudes. Rainfall, of course, affects vegetation by its influence on evaporation and soil moisture; but in the case of Mount Maquiling these factors seem to be influenced more by changes in humidity, due to the ascent of air, than by rainfall. Humidity increases with rising elevations clear to the top of the mountain, whereas rainfall is greatest at elevations below the top. The amount of soil moisture also increases with rising elevations, clear to the top of the mountain, while evaporation decreases. The rainfall on Mount Maquiling cannot be considered exceptionally heavy at any elevation; but at all altitudes above 80 meters it would appear, according to the data given by Schimper, to be more than sufficient for the development of a tropical rain forest. That this is so is shown by the fact that at an elevation of 300 meters, where there is less rainfall than at higher elevations, such a forest is well developed. While the amount of rainfall at the base approaches the lower limits given by Schimper for a tropical rain forest, the indications are that this area also was originally covered by a tall rain forest. The type of vegetation seems to be influenced more by the distribution than by the actual amount of rainfall; provided, of course, that the total precipitation is not extremely small. This is particularly true in the Philippines as has been shown by Brown and Matthews.* At all elevations on Mount Maquiling the rainfall, as previously mentioned, shows a marked difference between the dry and the rainy seasons; but the dry season is short, and there is no long period during which there is no rainfall. A further consideration of the effect of rainfall on vegetation will be given in connection with soil moisture and evaporation.

In addition to the total amount of rain that falls, it is of interest to determine the amount that actually reaches the ground. This problem was suggested particularly by the fact that at the top of the mountain there are very frequently clouds which cause the condensation of water on the leaves, so that water actually drops from the trees when no rain is recorded in a gauge in the open. In order to try to determine the amount that actually reaches the ground under the mossy forest, two rain

* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), 9, 413-561.

gauges were placed under the main canopy. At first it was thought that the canopy was so even that there would be no difference in the amount of rain between two trees and near the trunk of a tree. Rain gauges were placed in these positions, and they showed considerable differences. The results from the two gauges for the year 1914, and also from the gauge in the open, are given in Table CII. For that year the gauge in the open showed a total rainfall of 245 centimeters; that between two trees, 310 centimeters; and that near the trunk of a tree, 150 centimeters. The average of the two gauges under the trees was 230 centimeters, which is 15 centimeters less than the total rainfall in the open. This would indicate that the amount of water which reaches the ground is actually somewhat less than that recorded in the open. The results from the two gauges are, however, not sufficient to make this conclusion positive.

TABLE CII.—*Total rainfall for periods of four weeks in the mossy forest on Mount Maquiling; altitude, 1,050 meters.*

[Rainfall is given in centimeters.]

Four weeks ending—	Position of gauge.		
	Open.	Under trees.	
		Near trunk of large tree.	Between two large trees.
1914.			
January 30	5.13	3.03	16.01
February 27	3.81	1.54	9.40
March 27	2.29	1.37	7.80
April 24	15.88	9.92	15.02
May 22	6.26	7.12	10.71
June 19	37.56	24.53	87.06
July 17	23.13	16.47	27.65
August 14	21.98	12.02	17.84
September 11	89.47	63.11	75.84
October 9	8.07	4.29	5.37
November 6	8.26	2.04	5.45
December 4	14.77	2.62	11.00
1915.			
January 1	8.84	1.58	20.57
Total	245.45	149.64	309.72

Two rain gauges were also placed in similar positions in the midmountain forest. The results are presented in Table CIII. In both cases the recorded rainfall was less than in the open. The average for the two gauges under the trees for the years

1913 and 1914 was 227 centimeters, whereas the average for these two years in the open was 272 centimeters, a difference of 45 centimeters.

TABLE CIII.—*Total rainfall for periods of four weeks in the midmountain forest on Mount Maquiling; altitude, 740 meters.*

[Rainfall is given in centimeters.]

Four weeks ending—	Position of gauge.		
	Open.	Under trees.	
		Near trunk of large tree.	Between two large trees.
1912.			
December 6	26.84	18.36	20.89
1913.			
January 3	20.35	17.86	17.75
Total	47.19	36.22	38.64
1913.			
January 31	12.75	12.70	11.30
February 28	5.06	5.98	4.97
March 28	2.57	2.20	2.01
April 25	1.76	1.38	1.48
May 23	16.57	16.45	12.15
June 20	7.22	4.91	4.96
July 18	33.25	26.65	28.28
August 15	63.25	58.70	48.20
September 12	59.45	48.11	41.68
October 10	8.87	8.84	6.29
November 7	26.36	28.40	22.25
December 5	10.04	9.55	7.87
1914.			
January 2	19.69	19.09	13.83
Total	266.84	242.96	205.27
1914.			
January 30	4.75	4.54	3.56
February 27	3.35	3.03	2.62
March 27	2.13	1.36	1.49
April 24	13.37	14.71	7.80
May 22	6.23	5.62	5.13
June 19	48.07	44.80	38.37
July 17	31.14	27.51	21.67
August 14	21.22	18.23	20.64
September 11	102.66	97.02	81.05
October 9	11.19	12.54	7.94
November 6	6.71	4.38	2.86
December 4	17.43	15.37	7.17
1915.			
January 1	8.79	8.36	3.67
Total	277.04	257.47	203.97

SOIL MOISTURE

MOISTURE-HOLDING CAPACITY AND MOISTURE EQUIVALENT

The percentage of moisture in the soil, on the basis of the dry weight, at depths of 10, 20, and 30 centimeters, was determined weekly from November, 1912, to December, 1913, for the grassland area at an elevation of about 100 meters; the dipterocarp forest at 300 meters; the midmountain forest at 730 meters; and the mossy forest at 1,050 meters. The results have been presented by Brown and Argüelles.* It is important to know not only the moisture content of the soil at different times but also something of its water-holding capacity; and so both the water-holding capacity and the moisture equivalent of the soils at the various elevations have been determined. For this purpose a composite sample, amounting in each case to 20 liters of soil, was collected from the surface to a depth of 35 centimeters at each of the elevations above mentioned. This sample was thoroughly mixed, and the smaller samples used in making the actual determinations were obtained by the usual method of quartering. The samples employed may, therefore, be considered as representative. The water-holding capacity based on the dry weight was determined according to Hilgard's† method; that is, by using a column of soil 1 centimeter in height. The pans employed were obtained from the Plant World.

When the soil on Mount Maquiling is brought to the laboratory it contains numerous lumps which are not easily broken, but which disintegrate readily when wet. Owing to this fact and also to the presence of small amounts of gravel, it was thought advisable to determine the water-holding capacity not only of the whole sample but also of samples passed through a 2-millimeter sieve. The results of these two sets of determinations are given in Table CIV. An examination of this table shows that all of the soils have a very high water-holding capacity, and that the capacity of the whole sample and that of the sample passed

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* Brown, W. H., and Argüelles, A. S., The composition and moisture content of the soils in the types of vegetation at different elevations on Mount Maquiling, *Phil Journ. Sci., Sec. A* (1917), 12, 221–232.

† Hilgard, E. W., Soils, N. Y. (1906), 209.

TABLE CIV.—*Water-holding capacity and moisture equivalents of soils at different elevations on Mount Maquiling.*

Type of vegetation.	Altitude.	Moisture-holding capacity.		Moisture equivalent of whole sample.
		Whole sample.	Sample passed through 2-mm. sieve.	
	Meters.			
Parang	100	89.8	91.3	48.7
Dipterocarp forest	300	96.3	96.6	45.9
Midmountain forest	730	96.9	97.8	45.5
Mossy forest	1,050	170.5	183.6	97.2

through the 2-millimeter sieve was in all cases very similar. This would indicate that, in determining the amount of water in the soil at any given time, errors due to variation in the size of particles in individual samples should be negligible.

The water-holding capacity of the soil in the dipterocarp and midmountain forests was practically the same, being, respectively, 96.3 per cent and 96.9 per cent; while that in the parang was slightly less, 89.8 per cent. The mossy forest has a much higher water-holding capacity, 170.5 per cent. This high capacity for retaining moisture is probably connected with the large amount of organic matter contained in the soil in that region. The composition of the various soils has been given under the heading of chemical and physical composition of soils.

The moisture equivalent of the different soils was determined according to the method of Briggs and Shantz;* that is, a column of soil 0.5 centimeter in height was subjected for half an hour to a centrifugal force equivalent to one thousand times gravity, and the percentage of water left in the soil calculated on the basis of the dry weight. In order to make the determination without using the special type of centrifuge designed by these authors, a new type of cup was devised. This consisted essentially of two brass tubes, one fitting into the other but not reaching to the bottom of the latter. The soil was placed in the inner tube, the bottom of which was perforated with numerous small holes so that the water thrown from the soil was held in the outer tube. In this way the equilibrium of the machine was

* Briggs, L. J., and Shantz, H. L., The wilting coefficient for different plants and its indirect determination, *Bull. U. S. Bur. Plant Industry* (1912), No. 230.

not disturbed. The bottom of the inner tube was first covered by a fine wire gauze with 200 meshes to the inch, and this gauze was covered by a piece of thin filter paper. The bottom of the tube was detachable and so constructed that when screwed onto the tube it held the wire gauze and the filter paper flat and in position. Apparently the only objection to these tubes is that with a column of soil 0.5 centimeter in height they hold only a small sample. This might give rise to serious errors with soil containing considerable quantities of gravel; but with the fine, uniform soils of Mount Maquiling the error was negligible. In every case duplicate determinations were made, and the results obtained from the same soil differed by about 1 per cent. The average results for the different soils are given in Table CIV. As might be expected from the high water-holding capacity, the moisture equivalents of all the soils were high, particularly so in the case of the soil from the mossy forest.

Briggs and Shantz * have made a very careful and exact study of the amount of water left in soils by plants when they become permanently wilted. In their work they introduced the term "wilting coefficient," which is defined as follows:

> The wilting coefficient is then defined as the moisture content of the soil (expressed as a percentage of the dry weight) at the time when the leaves of the plant growing in that soil first undergo a permanent reduction in the moisture content as a result of a deficiency in the soil-moisture supply. By a permanent reduction in the moisture content of the leaves is meant a condition from which they can not recover their turgor in an approximately saturated atmosphere without the addition of water to the soil.

As a result of their work they came to the following conclusion:

> The object of this investigation was to determine the extent of the variation exhibited by different plants with respect to the minimum point to which they can reduce the moisture content of the soil before permanent wilting occurs. It has heretofore been believed that plants differ widely in this respect and that drought resistance is in part due to the additional supply of water which is available to some plants through the greater force which they exert upon the soil moisture. The results of this investigation have led us to conclude that the differences exhibited by plants in this respect are much less than have heretofore been supposed and are so small as to be of little practical utility from the standpoint of drought resistance. As compared with the great range in the wilting coefficient due to soil texture, the small differences arising from the use of different species of plants in determining the wilting coefficient become almost insignificant.

* Briggs, L. J., and Shantz, H. L., The wilting coefficient for different plants and its indirect determination. *Bull. U. S. Bur. Plant Industry* (1912), No. 230.

These authors give a number of indirect methods of determining the wilting coefficient.

$$\text{Wilting coefficient} = \frac{\text{moisture equivalent}}{1.84\ (1\pm0.0007)}.$$

$$\text{Wilting coefficient} = \frac{\text{hygroscopic coefficient}}{0.68\ (1\pm0.018)}.$$

$$\text{Wilting coefficient} = \frac{\text{moisture-holding capacity}-21}{2.90\ (1\pm0.021)}.$$

$$\text{Wilting coefficient} = \frac{0.01\ \text{sand-}0.12\ \text{silt-}0.57\ \text{clay}}{(1\pm0.025)}.$$

It will be seen that these formulas do not take into consideration the atmospheric conditions. Brown,* working in Arizona, found that plants wilted when the rate of evaporation was high with a greater amount of water in the soil than when the evaporation rate was low. Caldwell,† and Shive and Livingston, ‡ working in the same region, found that the permanent wilting of plants occurred with varying amounts of moisture in the soil, dependent upon the rates of evaporation, and so they concluded that the formulas of Briggs and Shantz were not of universal application. However, Caldwell as well as Shive and Livingston found that, when the plants were growing in a soil with a high water-holding capacity and were subjected to low rates of evaporation, the amount of water left in the soil when the plant became permanently wilted approximated that obtained by calculation from Briggs and Shantz's formula. This is shown by the following quotation: §

> The quantitative relations holding between the magnitude given to the calculated soil moisture residue at permanent wilting, by the Briggs and Shantz formula, and the observed magnitudes as shown in these experiments, remains to be considered. Caldwell has shown that, for lighter soils (with low water holding powers), the observed values are always much larger than the calculated, this discrepancy being greater, of course, with high evaporation intensities than with lower ones. On the other hand, the same author has established the fact that, with heavier soils (of

* Brown, W. H., The relation of evaporation to the water content of the soil at the time of wilting, *Plant World* (1912), 15, 121–34.

† Caldwell, J. S., The relation of environmental conditions to the phenomenon of permanent wilting in plants, *Physiol. Res.* (1913), 1, 1–56.

‡ Shive, J. W., and Livingston, B. E., The relation of atmospheric evaporating power to soil moisture content at permanent wilting in plants, *Plant World* (1914), 17, 81–121.

§ Shive and Livingston, op. cit.

high water holding powers), the observed values approach much more closely the calculated ones, being about equal to them under conditions of low evaporation intensities. These observations of Caldwell are clearly substantiated by the work here reported, excepting that the present experiments furnish a number of cases where the observed values fall markedly *below* the calculated ones (series V). As might be expected from Caldwell's results in this connection, these cases occur with low evaporation intensities and with the soil of highest water holding power.

The soils on Mount Maquiling, as we have seen, have a high water-holding capacity. The rate of evaporation near the ground in the virgin forest is moreover always low, and particularly so at higher elevations, and nowhere under the virgin forest does it approach the higher values that were obtained in Caldwell's and Shive and Livingston's experiments. Owing to this fact the wilting coefficient as obtained by the formulas of Briggs and Shantz will, for convenience, be tentatively employed as a rough measure of the amount of moisture that would be left in the soil on Mount Maquiling if plants became permanently wilted under the evaporation conditions existing near the ground. In Table CV are shown the wilting coefficients for the various

TABLE CV.—*Wilting coefficients of soils at different elevations on Mount Maquiling.*

Type of vegetation.	Altitude.	Wilting coefficient. Calculated from water-holding capacity.	Wilting coefficient. Calculated from moisture equivalent.	Average wilting coefficient.
	Meters.			
Parang	100	23.7	26.5	25.1
Dipterocarp forest	300	26.0	24.9	25.5
Midmountain forest	730	26.2	24.7	25.5
Mossy forest	1,050	51.6	52.8	52.2

soils as calculated from the water-holding capacity and from the moisture equivalent; also, the average of these two values. An examination of this table shows that the wilting coefficients as calculated by these two methods are similar in every case, and that all of the soils have a very high wilting coefficient.

In Tables CVI to CIX are given the percentages of moisture in the soils of the parang and in the dipterocarp, midmountain, and mossy forests for the period from November, 1912, to December, 1913. One of the most striking peculiarities of these tables is the similarity in the amount of moisture in any

given soil at different depths. This is apparently due to the fact that the dense covering of vegetation prevents the surface soil from drying out at a much more rapid rate than the deeper layers. The average percentages for four-week periods at a depth of 20 centimeters in the parang and in the dipterocarp and midmountain forests are plotted in fig. 14. In this curve

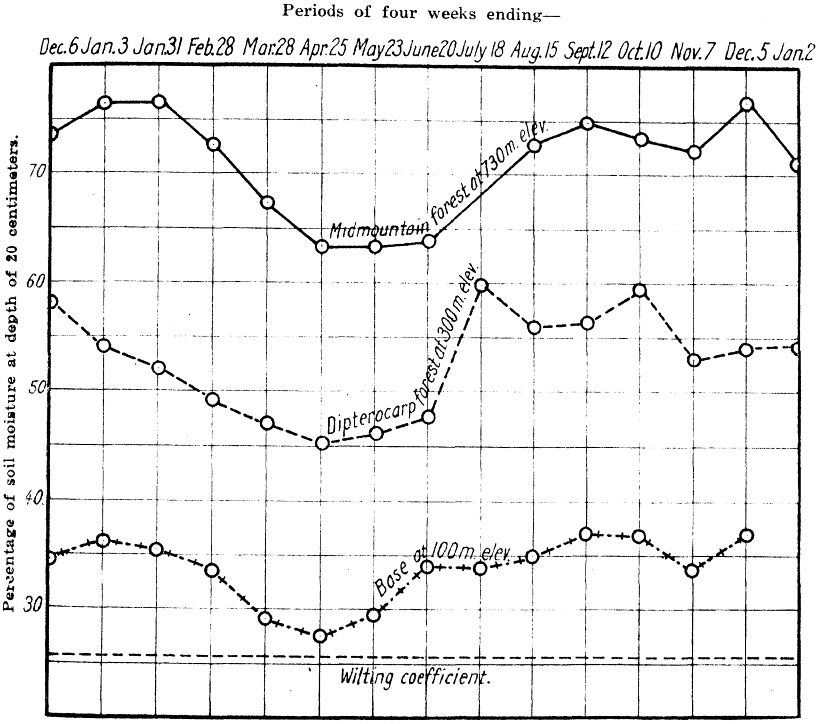

FIG. 14. Average weekly percentage of soil moisture on Mount Maquiling at a depth of 20 centimeters at different altitudes.

the wilting coefficient of the soil in the dipterocarp forest is shown as a straight line. The wilting coefficient of only one soil has been plotted, as the coefficients for the soils in the dipterocarp and midmountain forests are exactly the same and that for the parang is only 0.4 per cent lower than that of the other two. So slight a difference is within the limits of error indicated by the different values obtained by the use of the two methods employed in calculating the coefficient. For convenience in comparison, the wilting coefficient for the soil of the dipterocarp forest may, therefore, be considered the same as that for the other two soils.

SOIL MOISTURE IN THE PARANG

In Table CVI are given the percentages of moisture in the grassland at the base of Mount Maquiling at an altitude of 100 meters. From a comparison of this table with Table CIV it will be seen that no determination showed at any of the depths as great a quantity of water in the soil as 50 per cent of its water-holding capacity. From fig. 14 and from Table CVI it will be seen that the amount of water in the soil decreased during the dry season, beginning with January and continuing until April, and then increased until June, after which the percentage was fairly constant for the remainder of the year. During the latter part of March and the first part of April the amount of water in the soil, at depths of 10 and 20 centimeters, is about equal to the wilting coefficient, and only slightly higher than the wilting coefficient at a depth of 30 centimeters. As the rate of evaporation at this time of the year is high, it may well be that the amount of water near the surface is not sufficient

TABLE CVI.—*Percentage of soil moisture in the grassland at the base of Mount Maquiling; altitude, 100 meters.*

Date.	Depth in centimeters.			Date.	Depth in centimeters.		
	10.	20.	30.		10.	20.	30.
1912.				1913—Cont.			
December 6	30.3	34.5	33.6	May 2	27.6	27.5	27.8
December 13	34.1	34.7	35.5	May 9	27.0	26.8	27.1
December 20	35.6	34.6	35.3	May 16	33.8	28.7	30.3
December 27	36.9	35.7	35.6	May 23	34.3	34.8	32.8
1913.				May 30	33.3	32.7	33.1
January 3	38.5	39.4	39.1	June 6	30.8	30.3	31.9
January 10	38.7	35.5	37.6	June 20	33.2	38.8	29.9
January 17	34.1	38.1	39.8	July 18	40.9	33.9	35.1
January 24	37.6	36.4	37.6	July 25	33.9	35.7	36.0
January 31	34.2	33.4	33.3	August 1	35.8	34.8	35.7
February 7	30.3	30.4	31.5	August 8	36.4	36.1	35.6
February 14	33.2	34.6	35.5	August 15	37.7	33.5	34.7
February 21	35.8	33.6	33.0	August 22	38.3	35.1	36.8
February 28	35.6	34.6	33.6	August 29	39.7	36.8	35.2
March 7	35.6	34.8	38.5	September 5	38.9	39.2	40.1
March 14	31.2	32.4	33.8	September 26	38.7	35.8	40.6
March 21	27.2	25.6	28.3	October 3	36.6	37.8	36.9
March 28	25.8	23.3	28.3	October 24	35.1	34.3	33.4
April 4	25.0	29.3	28.6	November 7	33.6	32.7	31.7
April 11	24.1	24.2	27.7	November 14	31.8	35.4	34.3
April 18	29.2	26.5	27.1	November 21	41.3	38.7	42.6
April 25	30.5	30.6	33.4	November 28	39.1	37.1	38.1

for the growth of plants. Even the trees have a slower rate of growth and less-dense foliage at this time than at other times.

The low moisture content of the soil in the parang and the high evaporation rate at this elevation would indicate that the rapid rate of growth of plants in this area is not due to favorable moisture conditions, but rather to favorable illumination and temperature. The total range of soil moisture in the grassland is not particularly great, as the lowest determination was 23.3 per cent at a depth of 20 centimeters on March 28, and the highest was 42.6 per cent at a depth of 30 centimeters on November 21.

SOIL MOISTURE IN THE DIPTEROCARP FOREST

The percentage of moisture in the dipterocarp forest at an elevation of 300 meters is given in Table CVII. The water-holding capacity of this soil was 96.3 per cent, which is not much

TABLE CVII.—*Percentage of moisture in the soil in the dipterocarp forest on Mount Maquiling; altitude, 300 meters.*

Date.	Depth in centimeters.			Date.	Depth in centimeters.		
	10.	20.	30.		10.	20.	30.
1912.				1913—Cont.			
November 15	57.4	57.1	56.6	May 2	44.2	46.2	48.1
November 22	57.2	59.5	56.5	May 9	45.1	42.9	42.4
November 29	57.2	57.8	58.6	May 16	50.7	49.4	51.0
December 6	55.2	57.8	56.5	May 30	51.4	50.8	55.4
December 13	53.1	54.4	52.3	June 6	46.1	45.4	46.6
December 20	54.2	52.4	56.2	June 13	42.0	43.5	44.7
December 27	60.4	54.6	54.5	June 20	54.8	51.7	54.4
1913.				July 18	53.2	59.8	57.9
January 3	55.5	54.7	57.0	July 25	56.1	57.3	59.4
January 10	53.8	52.2	54.2	August 1	52.4	52.9	50.0
January 17	51.2	47.2	54.9	August 8	54.8	56.2	55.1
January 24	53.6	57.4	60.0	August 15	53.0	57.8	60.0
January 31	54.6	54.4	56.3	August 22	58.1	57.2	55.8
February 7	47.1	45.8	51.7	August 29	64.5	61.2	58.8
February 14	47.6	50.5	53.5	September 5	55.4	53.9	51.2
February 21	55.6	52.5	48.0	September 12	54.8	53.8	55.1
February 28	44.9	48.1	47.1	September 19	57.0	61.2	59.4
March 7	47.5	52.4	51.5	October 3	55.4	57.7	56.1
March 14	45.9	46.7	47.9	October 24	56.1	54.8	54.4
March 21	39.0	45.0	50.3	November 7	55.2	51.2	52.1
March 28	40.6	44.1	48.8	November 14	55.1	54.6	54.2
April 4	42.4	41.4	44.5	November 21	58.4	52.0	47.6
April 11	41.3	42.6	44.5	November 28	55.2	55.3	55.1
April 18	52.1	49.4	49.8	December 12	57.2	55.4	54.3
April 25	42.1	47.6	44.8	December 19	59.1	59.1	59.4
				December 26	51.2	48.1	50.8

greater than that of the parang, where it was 89.8 per cent. However, the amount of moisture in the soil in the dipterocarp forest is always much greater than in the parang, averaging about 20 per cent higher. The soil of the dipterocarp forest, like that of the parang, shows the lowest water content during the dry season. The lowest percentage of moisture observed was 39 at a depth of 10 centimeters on March 21. This percentage is much greater than the wilting coefficient, which is 25.5 per cent. From this it would appear that there should be sufficient moisture in the soil for plants at all times; but, as has been previously noted, the rate of growth of the trees is lower and the foliage much less dense during the dry season than at other times. This is probably due primarily, as will be pointed out later, to the relatively high rate of evaporation prevailing at this time.

SOIL MOISTURE IN THE MIDMOUNTAIN FOREST

The percentage of water in the soil in the midmountain forest at an elevation of 730 meters on Mount Maquiling is given in Table CVIII. The water-holding capacity of the soil

TABLE CVIII.—*Percentage of moisture in the soil in the midmountain forest on Mount Maquiling; altitude, 730 meters.*

Date.	Depth in centimeters.		
	10.	20.	30.
1912.			
November 16	82.9	73.7	76.8
November 23	68.2	71.2	70.3
November 30	73.5	72.3	77.7
December 7	75.0	78.1	77.8
December 14	78.0	76.2	74.5
December 21	72.7	74.5	73.5
December 28	79.0	78.1	76.8
1913.			
January 11	77.2	80.1	------
January 18	------	75.6	77.5
January 25	76.8	------	86.2
February 1	70.2	73.5	74.7
February 8	69.1	72.8	73.5
February 15	70.5	74.7	76.4
February 22	73.7	69.7	72.0
March 1	74.6	73.1	75.6
March 8	70.1	70.7	74.5
March 15	57.2	65.1	66.4
March 22	62.4	65.9	68.8
April 5	57.8	55.2	60.1
April 12	------	66.2	66.5
April 26	64.4	68.8	69.5
1913—Cont.			
May 3	59.1	58.8	62.0
May 10	61.7	63.1	62.9
May 17	59.2	67.8	65.2
May 31	------	62.9	55.2
June 7	64.9	63.6	65.7
June 14	58.9	60.6	62.0
June 21	69.1	68.3	70.1
July 19	82.9	------	80.1
July 26	70.7	71.0	78.7
August 2	71.9	74.5	73.4
August 23	70.8	77.6	70.5
August 30	67.8	72.7	71.7
September 6	------	74.6	69.3
September 20	68.2	74.9	71.3
September 27	73.1	70.7	73.8
October 4	74.9	71.3	72.6
October 25	65.8	71.4	78.1
November 1	64.3	64.6	66.9
November 8	74.9	80.4	82.3
November 29	80.9	76.2	74.1
December 6	73.1	77.3	83.2
December 13	68.1	71.1	74.0

at this station is almost identical with that for the dipterocarp forest, but the amount of water in the soil is always much greater than in the dipterocarp forest, averaging about 15 to 20 per cent higher. The lowest percentage of moisture was found during the dry season, just as was the case at lower elevations. The lowest percentage recorded, however, was 55.2, which is 57 per cent of the water-holding capacity of this soil and is more than twice as great as the wilting coefficient. The percentage of moisture in the soil is between 70 and 80 for a large portion of the year. There is, however, no indication that this amount is excessive, as the soil is well drained. A consideration of the amount of water in the soil at different times of the year would seem to indicate that at this altitude plants should always have sufficient moisture. The rate of evaporation is low, and there is no indication that plants suffer from adverse moisture conditions at any time. The high moisture content of the soil and the low rate of evaporation would appear to afford sufficient explanation of the existence of a ground covering of shallow-rooting mesophytic herbs.

SOIL MOISTURE IN THE MOSSY FOREST

The moisture content of the soil in the mossy forest is given in Table CIX. This table shows that the moisture content of the soil in this forest is extremely high. There was only one week when the determination showed less than 100 per cent of moisture, and on that occasion this was true of only two of the three depths. Equally striking was the variation from week to week, and at different depths in the same week. The different depths frequently showed a variation of more than 100 per cent on the same day. The high moisture content seems to be connected with the large amount of organic matter found in this soil. The amount of organic matter apparently varies greatly in different situations, and the variations in the water content shown in Table CIX are probably due more to the places from which samples were taken than to weekly change in the moisture content of the soil as a whole. The water-holding capacity of this soil, as determined in the laboratory, was 170.5 per cent, which is a considerably lower percentage of moisture than was shown by most of the weekly determinations of the amount of moisture in the soil. Owing to the great variations in the water content, which are apparently due to the difference in the soil, no great importance can be attached to the actual figures obtained for the water-holding capacity. As

TABLE CIX.—*Percentage of moisture in the soil in the mossy forest at the top of Mount Maquiling; altitude, 1,050 meters.*

Date.	Depth in centimeters.			Date.	Depth in centimeters.		
	10.	20.	30.		10.	20.	30.
1912.				1913—Cont.			
November 16	258.1	190.5	246.7	May 17	303.9	214.5	173.6
November 23	251.5	167.5	121.1	May 24	224.3	185.4	173.6
November 30	305.0	312.4	129.5	May 31	260.2	246.7	251.8
December 7	275.9	258.2	123.2	June 7	159.4	161.7	162.4
December 14	291.0	188.1	180.5	June 14	209.8	226.0	206.0
December 21	234.5	352.8	232.0	June 21	212.7	171.0	-------
1913.				July 19	-------	137.2	255.0
January 11	245.0	268.2	273.0	August 2	237.7	211.8	231.8
January 18	178.6	149.5	362.3	August 9	273.8	207.[illegible]	-------
February 1	130.5	234.3	305.8	August 16	-------	104.2	197.7
February 8	211.1	225.2	289.0	August 23	200.1	146.8	141.2
February 15	250.5	188.0	206.0	August 30	218.3	199.7	142.8
February 22	-------	320.2	319.9	September 27	238.0	257.1	-------
March 1	281.8	256.0	255.5	October 4	218.8	-------	173.1
March 8	257.2	198.8	198.6	October 18	148.1	164.2	256.2
March 15	221.2	264.9	232.1	October 25	159.9	305.5	247.9
March 22	203.6	221.8	257.2	November 8	185.7	186.1	302.0
March 29	306.3	114.6	-------	November 22	154.2	263.2	301.2
April 19	167.4	88.2	75.1	November 29	247.3	203.6	256.5
April 26	176.5	152.0	139.2	December 6	165.3	204.8	272.1
May 10	226.4	136.8	122.0	December 13	134.6	222.1	-------

the soil on which the determination was made was first brought to the laboratory and dried, changes in the high organic content may, of course, have caused it to lose some of its water-holding capacity before this capacity was determined.

RELATION OF SOIL MOISTURE TO VEGETATION

The moisture content shown by the soil in the mossy and midmountain forests is undoubtedly connected with the fact that the ground covering is composed of plants that require more moisture than do those found in the dipterocarp forest.

It does not seem probable, however, that the dwarfing of the vegetation is connected with this high water content. The great amount of water in the soil of the mossy forest is not due to heavy rains that would cause the soil to become leached, as the rainfall is about the same in amount here as in the area from which the soil samples were taken in the dipterocarp forest, and is considerably less than in the midmountain forest and in a large proportion of the dipterocarp forest. The soil of the mossy forest is, moreover, well drained, so that it must

be well aërated, and it has a springy consistency. The figures in Table LVIII show less acidity in the soil of the mossy forest than in that of the dipterocarp forest. There seems, therefore, to be no reason for considering the high moisture content of the soil as harmful. The moisture content of the soil of the mid-mountain forest would certainly not seem to be high enough to be deleterious to vegetation. The fact that the trees in this situation are much smaller than those in the dipterocarp forest is probably due to the same factors that have resulted in the stunted vegetation on the top of the mountain, the difference being that these factors are more pronounced at the top.

The above discussion indicates that the moisture content of the soil should be as favorable at high as at low altitudes, and so cannot be connected with the dwarfing of vegetation as higher altitudes are reached.

HUMIDITY

The relative humidity at the different elevations was measured by means of Draper recording hygrometers, which were placed in the same cases as the thermometers. The results are presented in Tables CX to CXXIII, in the form of weekly maxima and minima, means, and the averages of daily maxima and minima. The weekly figures are summarized for corresponding four-week periods, as was done with the figures for temperature. The means were obtained from the records by a planimeter. In using the planimeter with circular Draper recording hygrometer records the same error is introduced as that described in connection with temperature. As in the former case this error is negligible. If the humidity were 90 per cent for one half of each day and 60 per cent for the other half, the error due to the use of the planimeter would be less than 0.3 per cent. Such a variation in humidity was observed nowhere except at the base station, and it was seldom greatly exceeded at that place. The actual error for variations between 60 and 90 per cent would, of course, be much less than 0.3 per cent, as the maximum and minimum are maintained for only very short periods of time. We may safely conclude that the error in the figures presented here for the mean is considerably less than 0.1 per cent; which is, of course, much less than the error in the instrument and is within the limits of accuracy with which the records can be read.

HUMIDITY IN THE PARANG

The recording of humidity under the second-growth trees at the base of Mount Maquiling was begun in October, 1912, and continued until January, 1915. The results are presented in Table CX in the form of weekly maxima and minima, means, and averages of daily maxima and minima. The results are further summarized in Table CXI for corresponding four-week periods for the entire time. The mean humidity was 82.2 per cent; the average daily maximum, 90.7 per cent; and the average daily minimum, 68.6 per cent. The average daily range was, therefore, 22.1 per cent. These figures indicate a comparatively high humidity.

TABLE CX.—*Relative humidity under second-growth trees at the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give percentage of saturation.]

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1912.					
October 11	96.5	80.5	93.0	95.8	86.9
October 18	96.5	77.5	90.4	95.7	84.9
October 25	96.5	77.0	91.0	95.8	83.7
November 1	96.0	67.0	86.0	91.3	73.1
November 8	92.0	70.0	83.4	90.6	75.9
November 15	92.0	71.0	85.4	90.1	77.8
November 22	92.5	69.0	72.0	90.8	74.1
November 29	93.0	70.0	85.0	90.9	77.5
December 6	92.0	70.0	84.6	91.3	76.2
December 13	92.5	65.0	83.4	90.4	73.3
December 20	92.5	71.5	85.0	91.0	74.1
December 27	92.5	64.5	85.2	90.9	74.6
1913.					
January 3	92.5	70.0	87.2	91.5	80.7
Average	93.6	71.0	85.5	92.0	77.9
1913.					
January 10	93.0	73.0	86.4	91.1	76.9
January 17	92.5	67.0	86.0	91.8	75.6
January 24	93.0	57.0	84.0	91.5	68.9
January 31	91.5	59.5	83.2	89.6	72.2
February 7	92.5	64.0	85.2	91.1	72.7
February 14	90.5	57.5	82.0	89.6	65.9
February 21	93.0	55.0	80.4	90.6	63.8
February 28	92.0	58.0	82.2	91.3	68.0
March 7	94.0	62.0	83.0	90.7	74.1
March 14	92.0	55.5	81.2	91.0	63.6
March 21	92.5	45.0	75.0	90.0	54.0
March 28	93.5	46.0	75.0	92.4	52.2
April 4	92.5	50.0	77.2	91.6	57.3
April 11	93.0	45.0	78.2	92.1	54.8
April 18	94.0	64.5	85.2	92.9	72.4
April 25	93.0	58.0	81.0	91.1	63.3
May 2	94.0	50.0	79.4	91.9	56.8
May 9	95.0	75.0	88.2	93.3	79.5
May 16	95.0	60.0	82.4	93.4	67.5
May 23	94.0	50.5	83.0	93.2	63.2
May 30	94.5	62.5	85.0	92.7	70.6
June 6	95.0	57.0	82.0	92.8	63.6
June 13	93.0	56.5	81.0	92.4	59.9
June 20	95.0	57.5	84.0	92.9	65.3
June 27	93.5	65.0	85.0	92.6	69.4
July 4	94.0	64.0	85.4	93.0	69.8
July 18	92.5	69.0	87.2	91.6	77.3
July 25	93.0	69.0	84.2	90.9	73.9
August 1	92.0	63.5	83.4	90.4	72.7
August 8	92.0	67.0	85.0	90.4	71.4

TABLE CX.—*Relative humidity under second-growth trees at the base of Mount Maquiling; altitude, 80 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
1913.					
August 15	91.5	64.0	82.4	90.3	70.8
August 22	91.5	72.0	84.2	90.4	75.5
August 29	91.0	68.0	86.0	90.5	72.5
September 5	92.0	70.0	83.2	90.1	73.0
September 12	91.5	62.0	81.2	90.1	69.8
September 19	92.0	67.5	83.0	90.5	71.9
September 26	91.5	63.5	84.0	90.7	71.4
October 3	92.5	61.0	83.2	90.6	69.1
October 10	93.0	69.5	84.2	90.8	73.1
October 17	91.0	72.0	86.2	90.1	79.9
October 31	90.5	62.0	77.0	88.5	71.4
November 7	92.5	70.5	85.0	90.9	79.1
November 14	91.0	66.5	83.4	88.7	73.5
November 21	90.5	66.5	82.2	89.9	74.3
November 28	90.5	66.0	82.4	88.0	74.6
December 5	92.0	69.5	83.0	89.6	72.9
December 12	91.5	66.5	84.4	88.1	73.4
December 19	91.0	73.5	85.2	90.5	80.2
December 26	91.0	66.0	85.0	89.5	76.6
1914.					
January 2	91.5	70.0	83.0	88.5	77.4
Average	92.5	62.6	83.0	90.9	69.9
1914.					
January 9	91.5	63.0	83.2	88.8	71.4
January 16	91.0	61.0	79.0	87.1	67.6
January 23	91.5	57.0	80.0	89.0	66.4
January 30	90.0	56.5	80.0	87.1	62.6
February 6	93.0	57.5	79.0	89.5	62.6
February 13	91.0	57.0	80.2	89.2	67.0
February 20	91.0	45.0	76.0	88.0	52.8
February 27	91.5	25.0	75.2	90.1	51.8
March 6	90.0	50.5	78.0	87.8	64.1
March 13	92.0	46.5	76.0	89.3	54.9
March 20	91.0	41.5	74.0	89.7	52.4
March 27	91.5	38.0	74.0	88.6	51.1
April 3	90.0	43.5	73.0	88.7	51.9
April 10	92.5	54.0	81.0	89.9	65.8
April 17	92.5	52.0	74.6	89.6	59.5
April 24	92.0	54.0	79.0	90.5	61.6
May 1	92.0	42.0	76.0	90.1	50.0
May 8	92.0	46.0	75.0	90.7	55.1
May 15	92.5	48.5	77.4	91.0	55.4
May 22	92.5	48.5	80.0	91.5	59.6
May 29	92.5	51.0	77.4	90.4	55.9
June 5	93.0	56.0	84.0	91.2	69.1
June 12	93.0	58.0	81.0	90.9	63.7
June 19	94.0	56.5	83.2	92.1	70.9
June 26	92.0	66.5	87.0	91.6	74.6

TABLE CX.—*Relative humidity under second-growth trees at the base of Mount Maquiling; altitude, 80 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1914.					
July 3	93.0	69.5	84.0	91.2	72.6
July 10	92.5	61.0	82.4	90.5	70.6
July 17	93.0	64.0	80.0	87.9	69.8
July 24	92.5	72.5	87.0	91.7	76.6
July 31	93.0	65.0	84.0	91.1	68.6
August 7	93.0	56.0	83.0	91.6	61.1
August 14	94.5	70.0	86.0	91.8	75.0
August 21	93.0	62.0	84.0	92.5	71.1
August 28	93.0	63.5	75.4	84.6	68.4
September 4	91.5	79.5	85.2	87.1	83.2
September 11	91.5	71.5	85.2	90.2	77.7
September 18	93.0	70.0	85.0	91.2	75.0
September 25	92.0	63.0	83.0	91.4	68.5
October 2	92.0	66.0	86.0	91.7	74.2
October 9	92.0	69.5	84.2	91.0	76.3
October 16	92.0	68.0	82.0	90.0	72.1
October 23	92.0	59.0	84.2	90.7	71.5
October 30	92.5	60.0	82.2	89.9	67.8
November 6	92.5	63.0	82.2	90.5	69.0
November 13	91.5	58.5	83.0	90.2	69.0
November 20	92.5	66.0	82.2	90.9	71.7
November 27	92.5	62.5	82.0	90.8	68.5
December 4	92.5	73.5	86.0	91.3	78.7
December 11	92.5	68.0	85.0	91.1	74.2
December 18	92.0	61.0	84.2	90.9	70.9
December 25	92.5	62.5	84.0	91.0	74.4
1915.					
January 1	91.5	56.0	80.4	90.2	65.5
Average	92.1	58.4	81.1	90.1	66.5

The absolute maximum was 96.5 per cent, and the minimum was 25 per cent. The latter figure was very exceptional and was accompanied by rather peculiar circumstances. At the time the writer was living in a large bamboo house at the forest station. On particularly dry days bamboo is sometimes noticed to crack, and on this occasion there was an unusual amount of cracking. This led to an examination of the hygrometer, which was recording a relative humidity of 25 per cent. The figure was so very low that it was checked with a sling psychrometer and found to be correct. On examining the records for the week at the different stations, it was found that they all showed a remarkably low humidity on that day. This record of 25 per cent was considerably lower than any other

reading obtained, and there was no apparent reason to account for it, as the temperature was not unusually high.

TABLE CXI.—*Relative humidity for periods of four weeks from October, 1912, to January, 1915, under second-growth trees at the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give percentage of saturation.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
January 31	93.0	56.5	82.8	89.5	70.2
February 28	93.0	25.0	80.1	90.0	63.1
March 28	94.0	38.0	77.1	90.0	58.3
April 25	94.0	43.5	78.7	90.8	60.9
May 23	95.0	42.0	80.2	91.9	60.9
June 20	95.0	51.0	82.2	92.0	64.9
July 18	94.0	61.0	84.7	91.4	72.1
August 15	94.5	56.0	84.4	91.1	71.3
September 12	93.0	62.0	83.1	89.5	73.9
October 10	93.0	61.0	84.1	91.0	72.5
November 7	96.5	59.0	84.4	91.2	75.4
December 5	93.0	58.5	82.6	90.2	74.1
January 2	92.5	56.0	83.7	90.3	74.6
Average	93.9	51.5	82.2	90.7	68.6

An examination of Table CX shows that there was no week in which the maximum humidity was not over 90 per cent, no week in which the average maximum was less than 84 per cent, and only one week during which it was less than 87 per cent. As the high humidities occur at night, it is evident that the humidity is always high at that time. The highest mean humidity occurred during the rainy season and the lowest during the dry season, particularly in March and April. The average daily maximum humidity showed very little variation at different times of the year. The average daily minimum was lowest during the dry season, beginning with February and ending in May. The highest average minimum, however, does not occur in the rainy season, but during November, December, and January, when the temperature and light intensity are both low.

In fig. 15 are plotted the maxima, minima, average daily maxima, average daily minima, and means for corresponding four-week periods. The curves for the maxima and the average daily maxima have the same general form and show but little variation with the seasons. The mean is considerably

lower in the dry season than at other times. The effect of the dry season is most marked in the curves for the average daily minima and the minima.

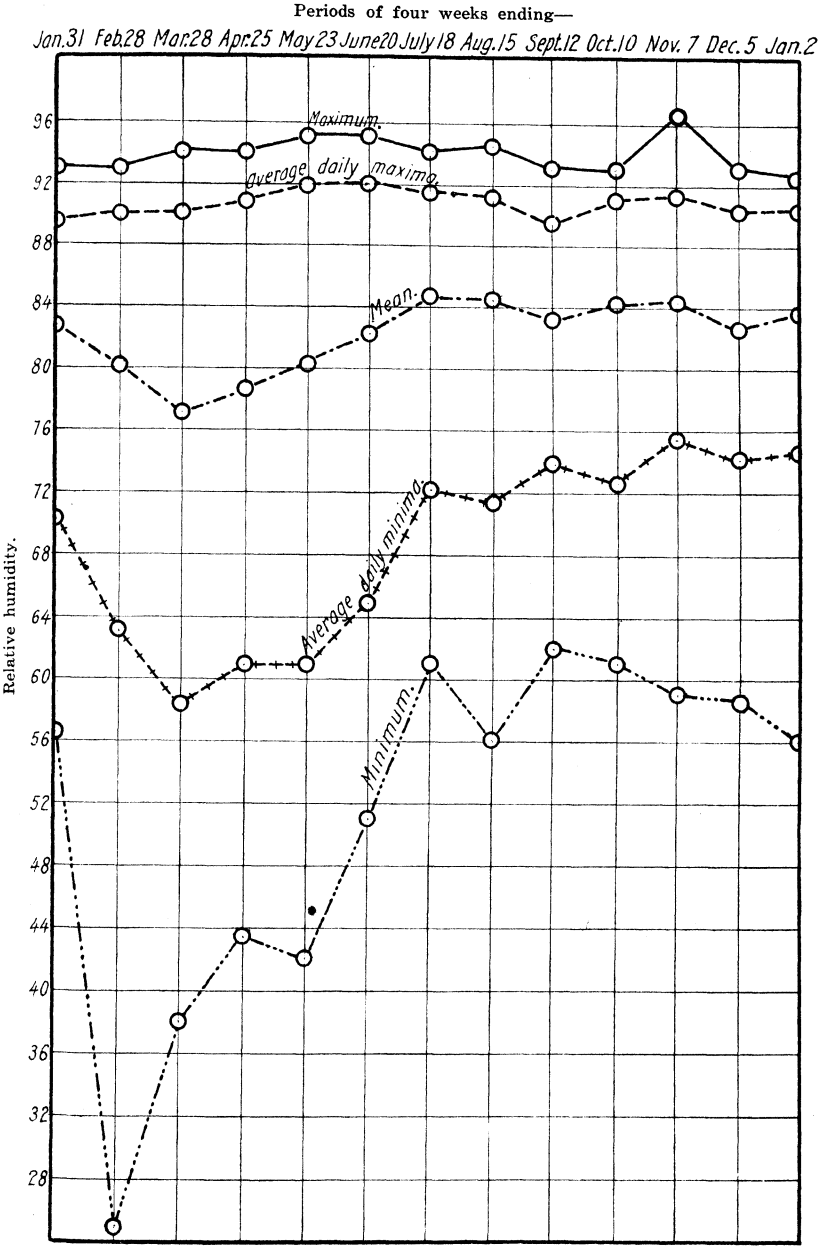

FIG. 15. Relative humidity under second-growth trees at the base of Mount Maquiling; altitude, 80 meters.

HUMIDITY IN THE DIPTEROCARP FOREST

The recording hygrometers in the dipterocarp forest were placed in the same cases as the recording thermometers. The results at an elevation of 300 meters are given in Table CXII in the form of weekly maxima and minima, means, and average daily maxima and minima; and are summarized for the entire period in Table CXIII in the form of maxima, minima, means, and averages of daily maxima and minima for corresponding four-week periods. The humidity under the forest at an elevation of 300 meters is considerably higher than in the parang at 80 meters, the mean humidity in the former location being 89.7 per cent, and in the latter, 82.2 per cent. The average daily maximum in the dipterocarp forest at 300 meters' elevation was 93 per cent, and the average daily minimum, 82.9 per cent. The absolute minimum was 47.5 per cent. This minimum occurred on the particularly dry day mentioned in the discussion of humidity in the parang. From an examination of Tables CXII and CXIII it will be seen that, with the exception of a very few days, the humidity in the forest at an elevation of 300 meters was relatively high and, moreover, fairly uniform, as the average daily variation was only 10.1 per cent. In the parang the variation was considerably greater, being 22.1 per cent. The smaller average daily range as well as the higher humidity in the dipterocarp forest is perhaps due in part to the higher elevation, but probably even more to conditions existing under the dense forest and to the large amount of water transpired by the foliage.

It will be noticed that the mean does not change with the seasons in exactly the same manner as does the mean at an elevation of 80 meters, the highest average means occurring during the colder months—November, December, and January—rather than during the rainy season, from July to September. The lowest means, however, are found during the dry season, from March to May. The average daily maxima and minima vary in much the same way as the means.

The maxima, minima, means, and average daily maxima and minima are plotted in fig. 16. As in the case of the parang, the curves for the average daily maxima and for the maxima are very similar in form. They both, however, show the effect of the dry season to a greater extent than the curves for the parang. Also, as in the parang, the curve for the mean shows the effect of the dry season more than do the curves for the max-

ima and minima; while this effect is again most marked for the average daily minima and for the minima.

TABLE CXII.—*Relative humidity in the undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 300 meters.*

[Numbers give percentage of saturation.]

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1913.					
May 30	96.0	79.0	90.2	94.1	84.3
June 6	96.0	75.5	91.5	95.1	81.1
June 13	97.0	73.5	89.3	95.3	76.4
June 20	96.0	74.0	91.3	95.1	82.9
June 27	95.0	83.0	90.7	93.7	86.8
July 4	94.5	82.5	92.0	93.9	87.0
July 11	96.0	84.5	92.0	93.8	88.3
July 18	93.0	85.0	91.4	92.0	89.3
July 25	93.0	84.5	90.1	91.8	85.8
August 1	93.0	78.0	89.4	91.0	85.5
August 8	93.0	80.0	90.2	91.5	85.3
August 15	93.5	80.0	89.4	91.8	83.6
August 22	94.5	85.0	90.2	92.4	88.0
August 29	93.0	86.0	89.0	92.1	87.5
September 5	93.9	85.0	91.4	92.1	86.3
September 12	95.0	77.0	90.2	93.0	84.7
September 19	94.0	82.0	90.0	93.1	85.6
September 26	94.0	82.0	92.0	93.0	87.0
October 3	94.0	79.0	91.0	93.0	85.1
October 10	96.0	86.0	93.2	94.3	88.5
October 17	95.0	84.0	93.0	94.3	89.2
October 24	95.5	83.0	93.3	94.5	88.0
October 31	96.0	75.0	89.6	94.1	84.2
November 7	96.0	89.0	93.3	94.9	91.7
November 14	96.5	86.5	92.0	94.2	88.9
November 21	97.0	86.0	94.2	96.3	91.5
November 28	97.0	86.5	94.3	96.3	91.5
December 5	96.5	87.0	93.2	95.8	90.0
December 12	96.0	87.0	94.1	95.5	91.8
December 19	96.5	92.0	94.4	95.5	94.0
December 26	96.5	86.0	94.2	95.8	92.3
1914.					
January 2	97.0	87.0	93.0	95.6	91.0
Average	95.2	82.8	91.7	93.9	87.3
1914.					
January 9	95.0	86.0	93.2	94.6	89.3
January 16	95.0	82.0	92.2	94.7	87.5
January 23	95.0	82.0	92.0	93.9	84.0
January 30	97.0	80.0	93.4	96.1	87.7
February 6	93.5	80.0	89.2	92.5	82.9
February 13	93.5	80.0	89.5	92.9	84.6
February 20	94.0	66.0	87.4	93.0	76.9
February 27	93.0	47.5	86.0	92.2	72.1
March 6	93.0	70.0	89.0	92.0	80.9

TABLE CXII.—*Relative humidity in the undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 300 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
1914.					
March 13	92.0	65.5	86.0	91.3	73.2
March 20	92.0	57.5	84.2	91.6	70.4
March 27	91.5	57.0	84.0	90.6	68.1
April 3	91.5	60.0	82.0	91.0	67.4
April 10	92.0	73.0	87.2	91.2	80.9
April 17	91.0	69.0	86.0	89.9	75.8
April 24	91.0	70.0	86.2	89.7	76.9
May 1	91.9	58.5	84.0	90.9	65.9
May 8	92.5	61.0	83.4	91.4	70.4
May 15	92.0	63.5	86.0	91.2	71.8
May 22	91.5	62.0	85.4	91.1	74.3
May 29	92.0	66.0	86.0	91.1	71.8
June 5	92.0	73.5	89.0	91.1	83.5
June 12	92.0	72.0	88.0	91.7	80.8
June 19	93.0	71.0	89.4	91.6	82.3
June 26	93.0	82.0	90.0	92.3	86.7
July 3	93.0	83.0	89.4	92.2	85.9
July 10	92.5	76.0	88.4	91.0	83.6
July 17	93.0	78.0	87.0	90.8	83.0
July 24	93.0	86.5	92.0	92.6	88.9
July 31	94.0	82.5	89.4	92.9	84.1
August 7	93.5	76.0	88.4	93.1	78.9
August 14	94.5	80.5	90.4	92.9	86.1
August 21	94.5	76.8	89.0	93.1	83.3
August 28	94.5	75.5	85.0	88.8	79.9
September 4	94.0	78.0	92.0	93.1	87.1
September 11	94.5	82.5	91.2	92.8	86.8
September 18	94.5	84.0	91.4	93.7	88.2
September 25	94.5	77.0	90.4	93.2	85.0
October 2	94.0	83.6	91.2	93.2	87.1
October 9	94.0	84.0	91.4	93.1	88.9
October 23	95.0	80.0	92.4	94.3	88.6
October 30	96.0	79.0	91.2	93.0	86.6
November 6	95.0	85.0	91.4	94.5	87.9
November 13	95.0	82.0	92.0	94.3	87.8
November 20	95.5	84.5	92.2	94.5	88.9
November 27	97.0	82.0	93.0	95.7	88.2
December 4	98.0	91.5	94.2	95.6	93.7
December 11	96.0	91.0	94.0	95.6	92.3
December 18	95.5	84.8	93.2	94.8	89.4
December 25	95.5	81.0	93.2	94.6	90.3
1915.					
January 1	96.5	81.0	92.4	93.7	86.3
Average	93.8	75.7	89.3	92.7	82.4

TABLE CXIII.—*Relative humidity for periods of four weeks from May, 1913, to January, 1915, in the undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 300 meters.*

[Numbers give percentage of saturation.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
January 30	97.0	80.0	92.7	94.8	87.1
February 27	94.0	47.5	88.0	92.6	79.1
March 27	93.0	57.0	85.8	91.4	73.1
April 24	92.0	60.0	85.3	90.4	75.2
May 22	92.5	58.5	84.7	91.1	70.6
June 19	97.0	66.0	89.4	93.2	80.4
July 17	96.0	76.0	90.1	92.5	86.3
August 14	94.5	76.0	89.9	92.2	84.8
September 11	95.0	75.5	89.8	92.2	85.5
October 9	96.0	77.0	91.3	93.4	86.9
November 6	96.0	75.0	92.0	94.2	88.0
December 4	98.0	82.0	93.1	95.4	90.1
January 1	97.0	81.0	93.7	95.2	91.0
Average	95.2	70.1	89.7	93.0	82.9

The weekly records of humidity at an elevation of 450 meters are given in Table CXIV, and the figures are summarized in Table CXV. The humidity in the forest at 450 meters' elevation is very similar to that at 300 meters' elevation, but is slightly lower, the mean at 450 meters being 1.9 per cent lower than at 300 meters. The hygrometer at 450 meters' elevation was, however, on a more exposed ridge than that at an altitude of 300 meters. The mean humidity and the average daily minimum vary in much the same way at 450 meters as at 300 meters' elevation. The average daily maximum, however, does not appear to be any lower during the dry season than at other times.

At 450 meters' elevation a recording hygrometer was also placed in the open in the same case as the thermometer. This, however, was run only from the last week in April, 1914, to November 27, 1914. Even in this short period there were four weeks during which records were not obtained, as the machine was an old one and the clock did not work well. The weekly results are given in Table CXVI and are summarized in Table CXVII. Table CXVII presents some rather interesting features. For the sake of comparing the humidity in the

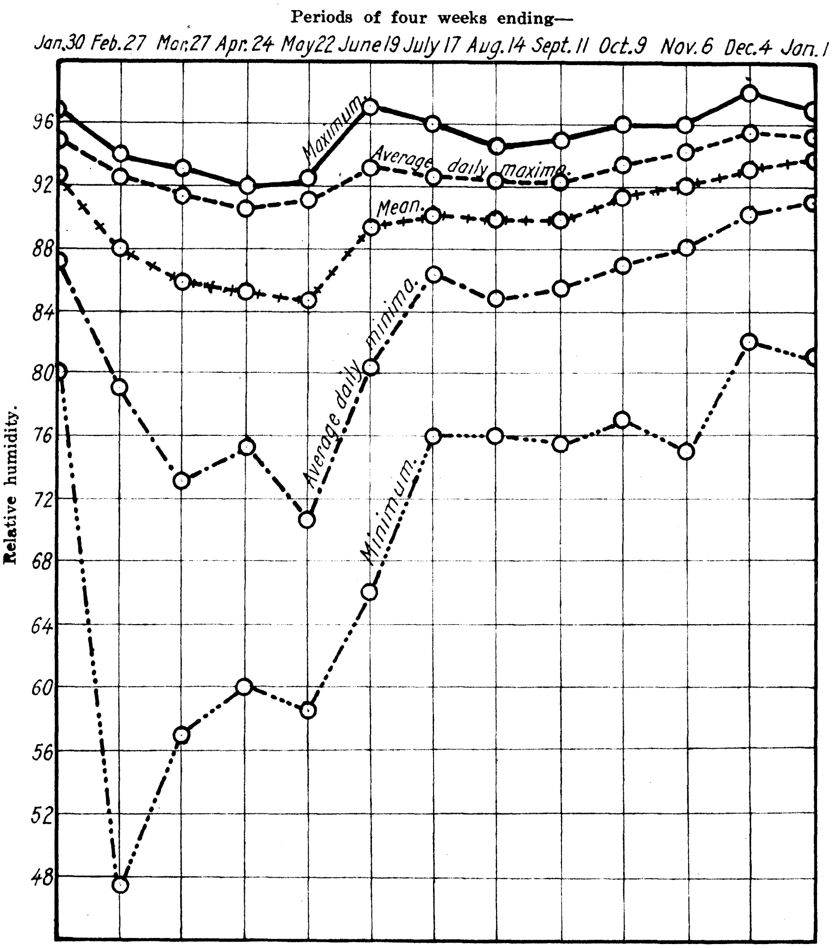

FIG. 16. Relative humidity in undergrowth in dipterocarp forest; altitude, 300 meters.

TABLE CXIV.—*Relative humidity in the undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Numbers give percentage of saturation.]

Week ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
1913.					
August 1	91.0	84.0	86.2	89.2	85.8
August 8	91.0	73.5	87.0	89.9	81.4
August 15	93.0	74.5	86.0	90.5	81.3
August 22	91.5	83.0	88.0	90.7	85.7
August 29	92.0	82.0	87.8	90.6	84.7
September 5	92.0	83.5	88.0	91.0	86.0
September 12	93.0	78.0	86.0	90.3	83.7
September 19	93.0	75.5	87.4	91.3	82.3

TABLE CXIV.—*Relative humidity in the undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 450 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1913.					
September 26	93.0	77.5	88.6	91.4	84.1
October 3	92.5	71.0	85.0	91.3	78.8
October 10	93.0	77.5	88.4	91.6	82.9
October 17	92.0	78.0	88.4	90.8	85.6
October 24	92.0	76.0	88.2	90.8	83.2
October 31	93.5	64.0	85.4	91.6	77.7
November 7	94.0	83.0	90.2	91.1	86.6
November 14	93.5	79.0	91.2	92.4	86.4
November 21	94.0	78.5	90.4	93.5	86.3
November 28	94.5	78.0	91.2	93.1	87.5
December 5	94.5	83.0	91.6	93.6	87.9
December 12	94.5	85.0	91.6	93.0	89.9
December 19	94.5	90.0	91.6	93.1	90.7
December 26	94.5	88.0	92.0	93.1	90.4
1914.					
January 2	93.4	85.5	91.0	92.2	89.5
Average	93.0	79.5	88.7	91.6	85.1
1914.					
January 9	94.0	83.0	90.4	92.3	86.5
January 16	94.0	76.0	89.2	92.5	82.9
January 23	97.9	77.0	92.0	97.1	84.3
January 30	94.0	76.5	89.0	92.6	79.6
February 6	95.0	74.0	88.4	93.5	79.6
February 13	94.0	77.0	89.0	92.5	84.7
February 20	93.0	59.5	85.0	91.1	70.9
February 27	96.0	45.0	84.4	93.3	70.7
March 6	93.0	66.0	88.0	92.1	79.5
March 13	92.0	54.0	84.2	91.5	70.5
March 20	99.0	54.0	82.2	93.4	68.2
March 27	94.0	53.0	84.0	93.0	66.6
April 3	98.0	59.5	81.2	92.5	67.1
April 10	93.0	74.2	89.0	92.4	81.5
April 17	93.0	71.0	86.2	91.9	76.5
April 24	93.0	63.0	87.2	91.5	76.8
May 1	91.5	56.5	81.0	90.4	64.6
May 8	94.9	65.0	84.6	93.1	72.2
May 15	94.9	62.1	87.0	93.3	72.6
May 22	95.0	65.5	87.2	93.1	77.3
May 29	95.0	66.0	85.0	93.0	72.1
June 5	95.0	73.5	89.4	92.5	84.1
June 12	93.5	74.2	87.0	92.3	79.1
June 19	94.0	68.0	90.0	92.6	81.8
June 26	93.0	79.5	89.4	91.9	85.8
July 3	93.5	82.0	89.0	92.5	86.6
July 10	92.5	80.0	89.0	90.8	86.6
July 17	93.5	78.5	88.2	92.0	85.0
July 24	93.0	88.0	90.2	91.7	89.1

TABLE CXIV.—*Relative humidity in the undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 450 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1914.					
July 31	94.5	72.0	88.0	91.5	79.8
August 7	93.9	72.0	87.0	93.1	77.1
August 14	92.5	82.0	90.4	91.8	86.9
August 21	94.5	75.1	88.4	92.3	83.5
August 28	95.5	78.0	86.0	90.3	82.1
September 4	92.0	82.0	90.0	91.1	88.6
September 11	92.5	87.5	90.4	90.8	88.5
September 18	93.5	76.0	89.4	92.4	82.0
September 25	93.0	79.5	88.0	91.2	84.1
October 2	93.0	82.0	90.2	92.3	87.7
October 9	93.0	82.2	90.0	91.9	87.2
October 16	93.0	81.5	88.0	91.1	85.4
October 23	93.0	77.0	90.0	91.9	86.8
October 30	92.5	78.0	89.0	91.6	85.8
November 6	92.5	84.0	89.2	91.4	85.5
November 13	93.0	79.0	89.4	92.1	85.6
November 20	93.0	83.2	89.2	92.0	86.5
November 27	93.0	78.0	88.0	92.1	86.6
December 4	92.0	87.5	90.0	91.4	89.8
December 11	92.0	87.5	90.0	91.5	89.1
December 18	91.5	80.0	89.0	91.0	86.8
December 25	92.0	84.0	88.4	91.4	88.8
1915.					
January 1	92.5	77.5	88.0	91.1	81.6
Average	93.7	74.0	87.9	92.1	81.3

open with that in the forest, Table CXVIII has been constructed, to show the relative humidity under the forest for the same four-week periods in 1914 as are covered by Table CXVII for humidity in the open. A comparison of these two tables shows that during the eight four-week periods the maximum humidity was greatest in the open for five periods, the same in both situations for one period, and greatest in the forest for two periods. The minimum for the four-week periods was always lower in the open than in the forest. The mean was higher sometimes in the forest and sometimes in the open. The average daily maximum was higher in the open for five periods, the same in both situations for one period, and higher in the forest for two periods. The average daily minimum was always considerably less in the open than in the forest. The lower minima in the open would appear to be due to the removal of the forest canopy, admitting of the freer movement of the

wind, which allowed the drier air above the tops of the trees to strike the hygrometer. That the maximum should be greater in some cases in the open and in others in the forest is probably due to various local conditions. When clouds come down from higher elevations, they lose some of their water content in passing through the canopy before they reach the hygrometer under the forest, whereas they have direct access to the hygrometer in the open. When, on the other hand, there was no such movement, the cooling at night of the humid air under the forest would produce a higher humidity than the cooling of the drier air which reached the hygrometer in the open.

TABLE CXV.—*Relative humidity for periods of four weeks from July, 1913, to January, 1915, in the undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Numbers give percentage of saturation.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
January 30	97.9	76.0	90.1	93.8	83.3
February 27	96.0	45.0	86.7	92.6	76.5
March 27	99.0	53.0	84.6	92.5	71.2
April 24	98.0	59.5	85.9	92.1	75.5
May 22	95.0	56.5	84.9	92.5	71.7
June 19	95.0	66.0	87.8	92.6	79.3
July 17	93.5	78.5	88.9	91.8	86.0
August 14	94.5	72.0	87.7	91.0	83.0
September 11	95.5	75.1	88.1	90.9	85.4
October 9	93.5	71.0	88.4	91.7	83.7
November 6	94.0	64.0	88.5	91.3	84.6
December 4	94.5	78.0	90.1	92.6	87.1
January 1	94.5	77.5	90.2	92.1	88.4
Average	95.5	67.1	87.8	92.1	81.2

HUMIDITY IN THE MIDMOUNTAIN FOREST

A recording hygrometer was also placed in the case with the recording thermometer at an elevation of 740 meters in the midmountain forest. The records are given in the form of weekly maxima, minima, means, and average daily maxima and minima in Table CXIX; and the results are summarized for corresponding four-week periods in Table CXX. The humidity at this elevation is slightly higher than in the dipterocarp forest at 450 meters' elevation. The mean humidity for the entire period in the midmountain forest was 90.4 per cent, and in the dipterocarp, 87.8 per cent, a difference of 2.6 per cent. The absolute maximum in the midmountain forest was 99.2 per cent, and the absolute minimum, 54.5 per cent. The

TABLE CXVI.—*Relative humidity for weekly periods in the open on Mount Maquiling; altitude, 450 meters.*

[Numbers give percentage of saturation.]

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima	Minima.
1914.					
May 1	94.3	54.5	83.2	95.5	61.3
May 8	93.0	60.5	85.0	95.7	66.8
May 15	96.5	58.0	86.4	96.7	67.4
May 22	96.0	58.0	86.4	96.6	67.4
June 12	92.0	60.0	82.0	91.0	66.1
June 19	92.5	63.5	85.2	90.7	71.9
June 26	92.0	66.5	86.4	91.4	75.0
July 3	93.5	72.5	87.2	92.8	76.3
July 10	92.5	69.0	87.4	91.1	78.9
July 17	94.5	64.5	87.0	93.1	76.0
July 24	93.5	73.6	89.2	92.7	78.0
July 31	94.5	66.0	87.0	92.9	73.0
August 7	94.5	63.0	85.0	93.9	66.6
August 14	94.5	74.0	91.2	93.4	81.1
August 21	95.0	64.0	87.4	93.7	76.1
September 11	88.5	85.5		88.5	85.5
September 18	94.5	68.0	85.4	89.3	77.1
September 25	96.5	70.5	84.5	89.6	74.6
October 2	97.0	73.0	86.7	90.9	78.8
October 9	97.0	73.5	87.3	91.7	80.2
October 16	98.5	72.0	92.0	96.8	78.6
October 23	98.5	68.0	94.5	97.5	82.3
October 30	98.9	71.0	93.0	97.6	79.4
November 6	98.0	76.2	92.7	97.4	79.4
November 13	98.0	73.8	93.3	97.6	79.3
November 20	98.7	76.0	93.1	97.5	80.6
November 27	98.8	69.5	92.5	96.0	79.6

TABLE CXVII.—*Relative humidity for periods of four weeks in the open on Mount Maquiling; altitude, 450 meters.*

[Numbers give percentage of saturation.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1914.					
May 22	96.5	54.5	85.3	96.1	65.7
June 19	92.5	60.0	83.6	90.9	69.0
July 17	94.5	64.5	87.0	92.1	76.6
August 14	94.5	63.0	88.1	93.2	74.7
September 11	95.0	64.0	87.4	91.1	80.8
October 9	97.0	68.0	86.0	90.4	77.7
November 6	98.9	68.0	93.1	97.3	79.9
December 4	98.8	69.5	93.0	97.0	79.8
Average	96.0	63.9	87.9	93.5	75.5

TABLE CXVIII.—*Relative humidity for periods of four weeks in the undergrowth in the dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Numbers give percentage of saturation.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1914.					
May 22	95.0	56.5	84.9	92.5	71.7
June 19	95.0	66.0	87.8	92.6	79.3
July 17	93.5	78.5	88.9	91.8	86.0
August 14	94.5	72.0	88.9	92.0	83.2
September 11	95.5	75.1	88.7	91.1	85.7
October 9	93.5	76.0	89.4	92.0	85.3
November 6	93.0	77.0	89.0	91.5	85.9
December 4	93.0	78.0	89.1	91.9	87.1
Average			88.3	91.9	83.0

average daily maximum was 93.5 per cent, and the average daily minimum, 85.7 per cent, a difference of 7.8 per cent, which is less than the average daily variation at 450 meters' elevation, where the average daily range was 10.9 per cent. The figures in Tables CXIX and CXX show that with the exception of short periods of a few days the humidity in the midmountain forest was always high and was, moreover, very even.

TABLE CXIX.—*Relative humidity in the midmountain forest on Mount Maquiling; altitude, 740 meters.*

[Numbers give percentage of saturation.]

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1913.					
June 13	97.5	76.0	89.2	96.1	77.7
June 20	97.6	78.5	92.2	96.7	84.5
June 27	99.2	75.5	91.4	97.4	83.5
July 4	92.5	74.0	89.0	91.1	83.9
July 11	98.0	85.5	94.0	95.6	90.9
July 18	97.5	84.0	93.2	95.5	90.7
July 25	95.5	91.2	93.4	94.7	93.1
August 1	96.5	84.5	93.2	95.2	89.6
August 8	94.5	82.0	91.3	93.1	86.8
August 15	96.3	83.0	91.4	94.7	85.3
August 22	95.5	81.0	91.2	93.8	86.8
August 29	96.0	80.2	91.2	94.4	86.5
September 5	97.0	79.0	91.1	94.5	87.5
September 12	96.5	77.5	90.2	93.5	86.0
September 19	96.5	79.5	89.1	94.8	85.9
September 26	97.2	83.5	93.0	95.8	88.9

TABLE CXIX.—*Relative humidity in the midmountain forest on Mount Maquiling; altitude, 740 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Minima.
1913.					
October 3	93.5	69.3	86.2	91.4	78.5
October 10	94.5	83.0	90.6	93.3	88.5
October 17	95.5	81.8	91.0	93.7	86.5
October 24	94.7	88.0	92.2	93.6	90.6
October 31	94.5	75.0	91.0	93.8	86.2
November 7	94.5	71.6	91.4	92.5	87.0
November 14	98.0	91.0	92.6	94.5	91.8
November 21	96.5	89.0	93.0	94.5	91.2
November 28	95.0	87.5	92.2	93.3	90.7
December 5	95.0	89.7	92.0	93.2	90.8
December 12	93.5	89.5	92.2	92.3	90.9
December 19	95.0	90.3	92.0	93.4	91.5
December 26	95.5	88.5	92.2	93.4	91.1
1914.					
January 2	94.5	90.0	90.2	92.6	91.4
Average	95.8	82.6	91.4	94.1	87.8
1914.					
January 9	93.5	85.0	91.2	92.6	89.7
January 16	94.0	87.0	92.0	92.6	89.9
January 23	93.0	85.0	91.2	92.8	89.2
January 30	94.5	86.9	92.3	92.9	89.3
February 6	94.5	85.5	91.1	93.2	87.9
February 13	95.0	84.5	91.4	93.3	89.5
February 20	94.0	70.0	87.3	92.5	79.0
February 27	95.0	54.5	87.2	93.9	76.6
March 6	93.5	83.0	90.0	92.3	87.8
March 13	94.8	55.0	87.0	93.5	77.1
March 20	95.5	57.0	89.4	93.8	78.4
March 27	94.5	64.5	89.4	93.6	78.6
April 3	95.0	66.0	89.0	93.7	79.2
April 10	94.0	82.0	89.4	93.2	88.8
April 17	94.0	79.0	89.3	93.0	83.1
April 24	94.5	75.0	89.2	92.8	86.0
May 1	94.0	62.2	86.4	93.8	71.5
May 8	95.0	66.1	89.0	93.7	80.0
May 15	95.0	72.5	89.2	93.9	79.2
May 22	96.0	67.2	89.0	93.2	79.9
May 29	95.5	73.1	89.0	94.4	77.2
June 5	95.5	80.0	91.0	93.0	87.7
June 12	95.5	77.0	90.0	94.2	82.1
June 19	95.0	73.1	90.4	93.7	85.6
June 26	93.0	80.0	90.0	92.8	87.2
July 3	94.0	79.5	89.2	93.1	84.2
July 10	94.0	82.0	89.4	92.3	87.5
July 17	92.5	81.0	90.0	91.9	86.7
July 24	95.5	85.5	92.4	94.6	89.9
July 31	97.0	65.0	89.2	94.6	80.5

TABLE CXIX.—*Relative humidity in the midmountain forest on Mount Maquiling; altitude, 740 meters*—Continued.

Week ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1914.					
August 7	96.5	76.0	90.0	95.6	80.8
August 14	98.2	85.0	92.0	96.1	90.0
August 21	96.3	76.1	91.2	95.0	86.0
August 28	95.0	84.0	91.0	93.8	88.5
September 4	94.0	89.0	91.4	93.1	91.0
September 11	93.0	89.1	92.0	92.4	91.2
September 18	94.0	67.0	88.2	92.9	80.0
September 25	98.0	74.0	91.0	95.7	82.9
October 9	96.0	89.0	93.2	94.8	91.2
October 16	95.5	86.0	92.2	93.9	89.3
October 23	94.5	85.2	91.4	93.3	89.9
October 30	94.0	85.5	91.0	92.5	89.2
November 6	93.0	89.0	91.4	92.4	90.1
November 13	93.0	86.5	91.0	92.4	89.4
November 20	93.0	87.5	91.4	91.9	89.9
November 27	93.0	84.0	91.2	91.7	88.4
December 4	92.0	88.0	91.0	91.5	90.0
December 11	92.0	87.0	89.2	90.6	89.1
December 18	93.0	86.0	89.2	90.9	87.9
December 25	92.0	80.0	90.0	91.1	87.9
1915.					
January 1	94.0	86.0	91.0	92.2	87.7
Average	94.4	78.5	90.2	93.2	85.5

TABLE CXX.—*Relative humidity for periods of four weeks from June, 1913, to January, 1915, in the midmountain forest on Mount Maquiling; altitude, 740 meters.*

[Numbers give percentage of saturation.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
January 30	94.5	85.0	91.7	92.6	89.5
February 27	95.0	54.5	89.2	93.2	83.3
March 27	95.5	55.0	88.9	93.3	80.5
April 24	95.0	66.0	89.2	93.1	84.3
May 22	96.0	62.2	88.4	93.5	77.7
June 19	97.6	73.1	90.4	95.1	82.2
July 17	99.2	74.0	90.8	93.7	86.9
August 14	98.2	65.0	91.6	94.8	87.0
September 11	97.0	76.1	91.2	93.8	88.0
October 9	98.0	67.0	90.3	94.2	85.1
November 6	95.5	71.6	91.5	93.2	88.6
December 4	98.0	84.0	91.8	92.9	90.8
January 1	95.5	80.0	90.7	92.1	89.7
Average	----------	----------	90.4	93.5	85.7

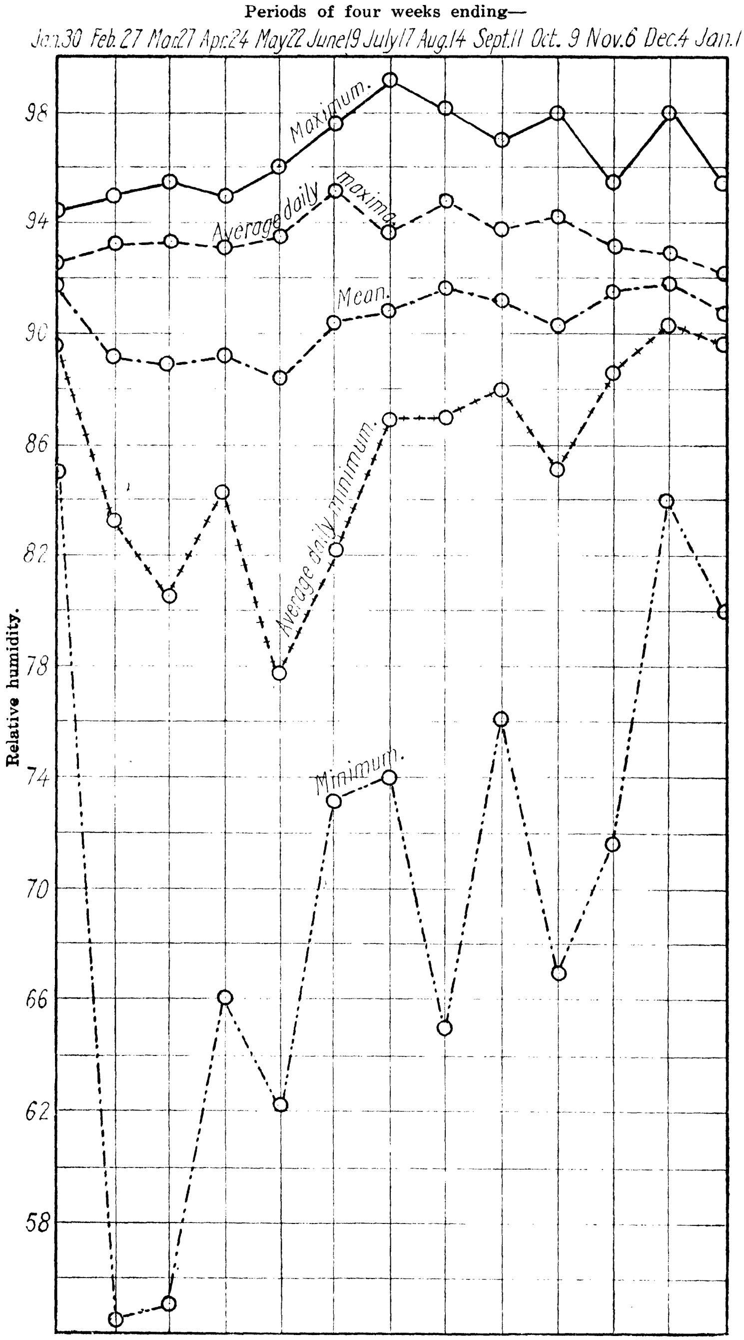

FIG. 17. Relative humidity in midmountain forest; altitude, 740 meters.

The maxima, minima, means, and average daily maxima and minima for four-week periods are plotted in fig. 17. These curves are similar in form to those for the lower elevations, but are more irregular.

HUMIDITY IN THE MOSSY FOREST

As at lower elevations, a recording hygrometer was placed in the case with the recording thermometer in the mossy forest at the top of Mount Maquiling. This hygrometer recorded 100 per cent humidity for practically the entire period, and there would be months at a time when the records did not

TABLE CXXI.—*Average daily maximum of relative humidity for periods of four weeks from May, 1913, to January, 1915, at different elevations on Mount Maquiling.*

[Numbers give percentage of saturation.]

Four weeks ending—	Elevation in meters.				
	80.	300.	450.		740.
			Forest.	Open.	
January 30	88.0	94.8	93.6		92.6
February 27	89.2	92.6	92.6		93.2
March 27	88.9	91.4	92.5		93.3
April 24	89.7	90.4	92.1		93.1
May 22	90.8	91.1	92.5	96.1	93.5
June 19	92.0	93.2	92.6	90.9	95.1
July 17	91.4	92.5	91.8	92.1	93.7
August 14	91.1	92.2	91.0	93.2	94.8
September 11	89.5	92.2	90.9	91.1	93.8
October 9	91.0	93.4	91.7	90.4	94.2
November 6	90.1	94.2	91.3	97.3	93.2
December 4	90.0	95.4	92.6	97.0	92.9
January 1	90.0	95.2	92.1		92.1
Average	90.1	93.0	92.1	93.5	93.5

indicate less than 100 per cent. This shows that the humidity at the top of the mountain was constantly high, but does not mean that the atmosphere under the forest was continually saturated, as the top of the mountain is in the cloud belt. The clouds not only cause the hygrometer to register 100 per cent, but also wet the hairs of the instrument so that, before it can record a lower humidity, the hairs must dry out to some extent. As the rate of evaporation is very low, short periods during which the air is not saturated may pass, and the top of the mountain again becomes bathed in clouds before the hairs have dried out sufficiently to record a humidity of less than 100

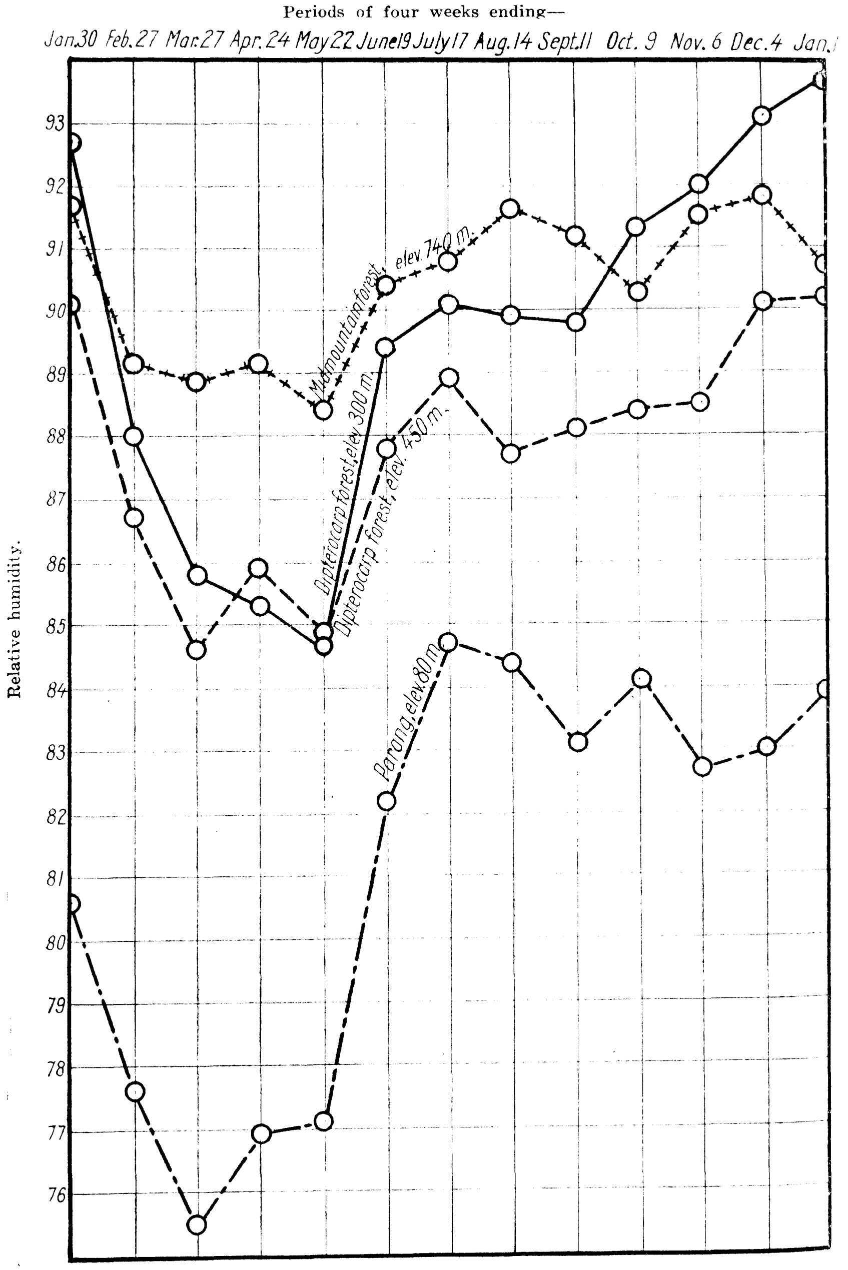

FIG. 18. Mean relative humidity under forest at different altitudes on Mount Maquiling.

per cent. The lowest humidity recorded by this instrument was 91 per cent. This occurred on only one day, and on no other occasion was anything like so low a humidity recorded. As the

TABLE CXXII.—*Average daily minimum of relative humidity for periods of four weeks from May, 1913, to January, 1915, at different elevations on Mount Maquiling.*

[Numbers give percentage of saturation.]

Four weeks ending—	Elevation in meters.				
	80.	300.	450.		740.
			Forest.	Open.	
January 30	67.0	87.1	83.3		89.5
February 27	58.6	79.1	76.5		83.3
March 27	55.6	73.1	71.2		80.5
April 24	59.7	75.2	75.5		84.3
May 22	55.0	70.6	71.7	65.7	77.7
June 19	64.9	80.4	79.3	69.0	82.2
July 17	72.1	86.3	86.0	76.6	86.9
August 14	71.3	84.8	83.0	74.7	87.0
September 11	73.9	85.5	85.4	80.8	88.0
October 9	72.5	86.9	83.7	77.7	85.1
November 6	73.5	88.0	84.6	79.9	88.6
December 4	72.9	90.1	87.1	79.8	90.3
January 1	74.1	91.0	88.4		89.7
Average	67.0	82.9	81.2	75.5	85.7

TABLE CXXIII.—*Mean relative humidity for periods of four weeks from May, 1913, to January, 1915, under the forest at different elevations on Mount Maquiling.*

[Numbers give percentage of saturation.]

Four weeks ending—	Elevation in meters.				
	80.	300.	450.		740.
			Forest.	Open.	
January 30	80.6	92.7	90.1		91.7
February 27	77.6	88.0	86.7		89.2
March 27	75.5	85.8	84.6		88.9
April 24	76.9	85.3	85.9		89.2
May 22	77.1	84.7	84.9	85.3	88.4
June 19	82.2	89.4	87.8	83.6	90.4
July 17	84.7	90.1	88.9	87.0	90.8
August 14	84.4	89.9	87.7	88.1	91.6
September 11	83.1	89.8	88.1	87.4	91.2
October 9	84.1	91.3	88.4	86.0	90.3
November 6	82.7	92.0	88.5	93.1	91.5
December 4	83.0	93.1	90.1	93.0	91.8
January 1	83.9	93.7	90.2		90.7
Average	81.2	89.7	87.8	87.9	90.4

records indicate a humidity of 100 per cent at almost all times and as they are inaccurate in the manner described, they are not presented, although they were taken for the entire period from October, 1912, to January, 1915. From the records we may conclude that the atmosphere under the forest is saturated or nearly saturated at almost all times.

HUMIDITY AT DIFFERENT ELEVATIONS

The average daily maxima, the average daily minima, and the mean humidities for four-week periods at the different elevations are shown in Tables CXXI, CXXII, and CXXIII. The means are plotted in fig. 18. An examination of this figure shows that the curves for all the different elevations have the

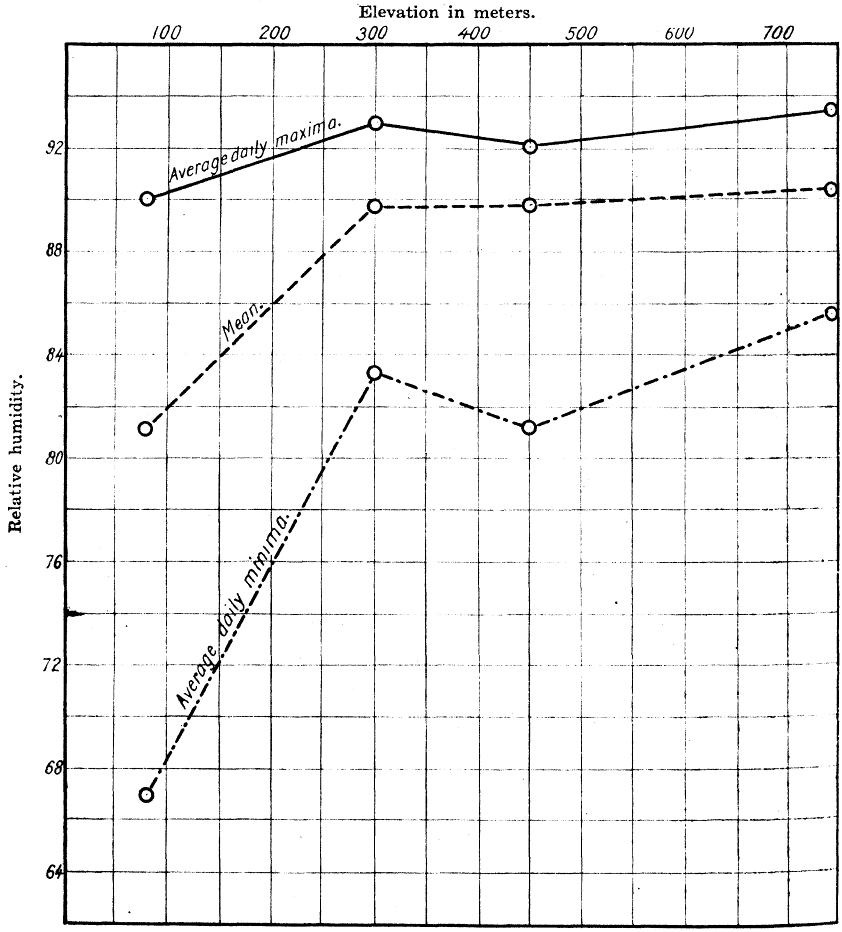

Fig. 19. Average daily maxima and minima and mean relative humidity at different altitudes on Mount Maquiling.

same general form. The difference between the dry and the wet seasons is very evident. Table CXXIII shows that the mean humidity at elevations of from 300 to 740 meters is very much higher than at 80 meters, but that there is comparatively little difference under the forest at the different elevations. The difference between the mean humidity at 300 meters and that at 740 meters is only 0.7 per cent. In fig. 19 the average daily minima, average daily maxima, and means for the different elevations are plotted for the entire period. This figure shows very clearly that the mean humidity increases considerably between elevations of 80 and 300 meters, but that there is very little difference in the mean at different elevations in the virgin forest up to 740 meters. The curve for the average daily minima shows an even greater difference between the humidity in the virgin forest and the humidity in the second-growth than does the curve for the mean. The average daily maxima are, however, not very different in the several cases. Humidity influences vegetation largely through its effect on evaporation, and so the discussion of the effect of humidity on vegetation will be deferred and given in connection with the discussion of evaporation.

EVAPORATION

Evaporation was measured by means of a Livingston rain-correcting atmometer, and all readings were reduced to the standard used by Livingston.* This form of atmometer consists essentially of a porous clay cup from which water is evaporated. The cup is so connected, by means of rubber stoppers and glass tubes, with a bottle containing water that the cup is kept constantly filled, the water that is evaporated from the moist surface being replaced by water from the bottle; while the backward flow of water from the cup is prevented by the insertion of a mercury valve.

The rates of evaporation were measured at the different stations in the tops of trees; near the ground, both on ridges and in ravines; and in some cases in the open. In the dipterocarp and the midmountain forests measurements were also taken in second-story trees. When an atmometer was placed in the top of a tree the end of the main stem was cut off and the crown trimmed as described in the discussion on temperature. An attempt was made to place these atmometers in such positions that they would be exposed to the same rates of evaporation as the upper surface of the crowns of the trees. To accomplish this exactly is very difficult, particularly as the trees are always growing and continual trimming is necessary. Variations in the shape of the crowns of the trees in which the instruments were placed probably caused some irregularities in the readings, but the general consistency of the results indicates that these were not serious. The glass bottles from which the atmometer cups obtained water were always inclosed in a perforated box, so that they might be screened from the direct action of sunlight. The cups which measured the rate of evaporation under the forest or in the open were placed about 25 centimeters above the soil surface. All cups were restandardized at frequent intervals.

Readings of the rates of evaporation were begun in November, 1912, and continued until January 1, 1915. In nearly all cases the results represent the average readings from two evap-

* Livingston, B. E., Atmometry and the porous cup atmometer, *Plant World* (1915), 18, 21.

orimeters and in some cases from more. A single evaporimeter was only used in ravines and in some cases near the ground under the trees.

EVAPORATION IN THE PARANG

All readings of evaporation in the parang were made weekly until July, 1913. Thereafter evaporation was measured daily in the top of a fairly tall second-growth tree, under the second-growth forest, in the lawn at the forest station, at the top of a small patch of *Saccharum*, and near the ground under the *Saccharum*. The atmometers at the top of the *Saccharum* were so placed as to give them the same exposure as that to which the tips of the leaves of the grass were subjected. As no such complete series of daily measurements of evaporation in the tropics are available, it has been thought worth while to give these readings in full, and they are presented in Table CXXIV. The measurements extend from July 1, 1913, to January 1, 1915. There were some days when it was impossible to take readings and these appear in the table as blanks, the evaporation for the following day being the summation for two days. In order that these figures may be considered conveniently, they are presented in a series of tables in the form of average daily rates, and maximum and minimum rates for corresponding four-week periods for the entire time. Such data for the top of the second-growth tree and the lawn are given in Table CXXV. The average daily evaporation for the entire period in the top of the tall tree was 21.1 cubic centimeters; the maximum, 51 cubic centimeters; and the minimum, 0.0. Zero readings appear in this table for the four-week periods ending July 17, September 11, and December 4. Reference to Table CXXIV will show that no evaporation was recorded on November 20, 1913; June 20, 1914; and September 4, 1914. The absence of any recorded evaporation on these days was due to periods of very rainy weather.

The average daily evaporation on the lawn was 19.7 cubic centimeters, or very little less than in the top of the second-growth tree. The atmometer in the lawn was, however, at the top of a small ridge and was about as fully exposed to the action of sun and wind as was the one in the top of the second-growth tree. The maximum in the lawn was 52.1 cubic centimeters, which is slightly greater than the maximum in the top of the second-growth tree. The minimum in the lawn was 0.0. On the same days on which no evaporation was recorded in the top of the second-growth tree the atmometer in the

TABLE CXXIV.—*Average daily evaporation in different situations near the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Date.	Top of a tall tree in second-growth forest.	Lawn.	In small patch of *Saccharum*.		Near ground under second-growth forest.
			At top of grass.	On ground under grass.	
1913.					
July 2	25.7	----------	18.0	----------	----------
July 3	17.9	13.8	10.5	----------	6.7
July 4	21.8	19.0	14.2	----------	6.7
July 5	17.7	13.1	9.7	----------	3.7
July 6	----------	----------	----------	----------	----------
July 7	37.0	26.2	21.7	----------	1.5
July 8	13.1	8.7	6.0	----------	3.7
July 9	22.0	16.8	14.2	----------	5.2
July 10	17.5	14.6	10.5	----------	4.5
July 11	18.2	13.8	10.5	----------	3.0
July 12	12.2	8.7	7.5	2.2	1.5
July 13	14.2	7.3	5.6	0.0	2.2
July 14	12.2	11.6	9.0	4.4	2.2
July 15	14.2	9.5	9.6	2.2	3.0
July 16	5.2	1.4	1.1	0.0	0.0
July 17	9.6	4.3	4.4	0.0	0.0
July 18	7.4	3.9	3.7	0.7	1.5
July 19	14.0	6.5	5.9	0.0	0.0
July 20	19.2	14.4	11.8	2.2	2.2
July 21	7.3	5.0	4.4	0.0	0.0
July 22	5.5	1.4	1.8	0.7	0.0
July 23	19.4	14.4	18.5	1.5	1.1
July 24	21.2	18.0	14.8	3.7	2.2
July 25	13.3	7.5	13.7	2.2	1.5
July 26	20.9	14.4	13.1	2.2	1.5
July 27	29.5	23.7	20.7	8.1	2.2
July 28	12.2	7.1	3.7	1.8	2.2
July 29	----------	1.4	0.7	0.0	0.0
July 30	26.2	5.3	4.4	0.0	0.0
July 31	24.5	13.8	13.8	1.4	2.2
August 1	14.0	7.4	6.5	0.7	0.7
August 2	15.4	9.9	8.0	1.1	1.5
August 3	17.5	11.4	9.5	1.8	1.5
August 4	12.4	8.5	7.3	1.4	1.1
August 5	4.1	2.1	1.4	0.0	0.0
August 6	13.1	9.2	7.3	0.7	1.5
August 7	22.4	9.9	8.7	2.5	2.2
August 8	21.9	15.4	13.9	2.9	3.7
August 9	28.0	19.1	17.4	2.9	3.7
August 10	41.9	32.6	29.9	1.1	8.3
August 11	26.6	21.3	19.9	6.6	4.5
August 12	24.5	16.4	15.3	6.6	4.5
August 13	14.9	10.0	10.2	1.4	2.2
August 14	15.5	10.6	10.5	1.4	1.9
August 15	12.5	7.7	7.5	0.03	0.7
August 16	39.6	26.2	25.6	7.2	5.2

TABLE CXXIV.—*Average daily evaporation in different situations near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Date.	Top of a tall tree in second-growth forest.	Lawn.	In small patch of *Saccharum*. At top of grass.	In small patch of *Saccharum*. On ground under grass.	Near ground under second-growth forest.
1913.					
August 17	9.8	3.8	3.1	1.4	1.1
August 18	18.6	11.0	11.0	1.4	1.5
August 19	19.1	13.9	15.3	2.1	4.5
August 20	19.1	14.5	16.3	5.0	3.4
August 21	9.8	5.0	4.5	0.0	0.0
August 22	10.5	5.5	6.0	1.4	1.6
August 23	14.7	10.9	9.2	5.0	2.2
August 24	15.1	9.3	9.9	5.0	1.9
August 25	13.6	10.1	9.5	0.7	1.7
August 26	17.0	10.2	8.9	0.1	1.3
August 27	8.6	5.2	3.9	0.0	0.0
August 28	17.1	12.1	10.5	0.8	1.6
August 29	16.3	10.7	10.8	1.2	1.6
August 30	14.1	11.1	8.7	0.9	1.9
August 31	21.1	13.5	13.6	2.5	2.0
September 1	21.2	14.3	13.5	4.1	3.2
September 2	21.0	14.9	15.3	4.3	1.6
September 3	11.4	10.1	8.7	1.3	1.4
September 4	34.4	20.6	17.9	2.5	3.0
September 5	31.0	24.8	20.6	5.5	4.4
September 6	33.7	24.3	20.2	4.5	4.6
September 7	31.2	21.7	19.4	8.4	4.6
September 8	25.2	19.5	15.9	5.7	3.8
September 9	37.5	28.1	24.1	6.6	4.3
September 10	12.5	9.5	6.4	1.4	0.6
September 11	1.2	1.5	0.4	0.0	0.0
September 12	11.1	7.0	5.1	0.0	0.0
September 13	18.7	12.9	11.5	1.7	1.7
September 14	23.8	17.3	16.1	4.1	3.4
September 15	22.5	16.0	14.4	4.8	2.5
September 16	35.5	26.6	22.9	9.0	5.8
September 17	20.9	16.6	13.5	4.8	2.3
September 18	20.8	15.2	13.2	2.5	1.9
September 19	16.2	12.4	11.7	2.6	3.3
September 20	15.8	12.8	11.3	1.3	0.1
September 21	21.7	16.1	14.8	2.3	2.4
September 22	23.2	18.5	16.4	4.4	3.9
September 23	19.9	15.6	14.2	4.0	3.3
September 24	20.8	16.7	15.0	4.3	3.7
September 25	13.5	9.8	7.1	0.0	0.0
September 26	5.3	2.6	1.3	0.0	0.0
September 27	14.3	10.3	8.0	0.0	0.0
September 28	21.3	16.0	14.5	0.0	0.0
September 29	21.0	13.4	14.6	1.2	6.0
September 30	16.6	11.9	11.0	2.5	1.7
October 1	22.9	19.4	17.6	3.8	3.8
October 2	24.5	18.9	17.3	5.1	3.6

TABLE CXXIV.—*Average daily evaporation in different situations near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Date.	Top of a tall tree in second-growth forest.	Lawn.	In small patch of *Saccharum*.		Near ground under second-growth forest.
			At top of grass.	On ground under grass.	
1913.					
October 3	23.7	17.5	17.6	4.6	3.0
October 4	19.3	12.9	11.9	0.9	2.0
October 5	22.8	16.1	12.4	1.7	3.1
October 6	10.0	12.1	9.6	0.0	0.0
October 7	16.0	11.4	9.9	2.5	2.3
October 8	17.5	12.9	11.7	1.5	1.9
October 9	19.3	17.2	15.7	2.2	2.3
October 10	19.3	15.8	15.6	2.7	2.9
October 11	16.3	12.8	11.3	2.1	1.9
October 12	1.8	0.0	0.0	0.0	0.0
October 13	1.8	1.3	1.4	0.0	0.0
October 14				0.0	0.0
October 15	17.4	10.9	10.1	0.0	0.0
October 16	17.5	19.6	18.4	1.8	5.5
October 17	12.0	6.6	6.7	0.0	0.0
October 18	22.7	16.9	17.0	2.6	3.8
October 19	18.5	14.3	12.8	2.2	2.5
October 20	15.5	12.2	12.1	2.0	2.2
October 21	18.0	13.8	12.0	2.8	2.7
October 22	20.5	15.0	14.6	3.3	3.3
October 23	22.8	16.5	17.1	4.5	3.7
October 24	25.3	11.5	16.2	3.5	4.3
October 25	28.7	21.6	17.9	4.8	5.2
October 26	28.1	20.3	17.1	4.3	4.6
October 27	25.3	20.2	18.1	5.8	5.3
October 28	22.6	17.8	16.8	3.4	4.6
October 29	22.4	17.0	14.8	3.1	4.7
October 30	24.9	19.5	17.8	3.7	5.1
October 31	31.6	21.9	21.0	5.0	6.0
November 1	14.7	8.3	6.8	1.0	2.0
November 2	13.4	11.9	9.2	2.3	2.5
November 3	15.7	12.7	11.3	2.7	3.3
November 4	14.7	12.8	11.7	1.7	2.2
November 5	3.7	2.9	1.6	0.0	0.0
November 6	6.4	4.3	2.5	0.0	0.0
November 7	17.7	15.8	12.1	1.0	2.7
November 8	8.1	7.1	4.3	0.0	0.0
November 9	9.6	5.1	2.6	0.0	0.0
November 10	13.3	12.5	9.6	0.0	0.0
November 11	7.5	5.1	1.5	0.0	0.0
November 12	18.4	14.0	9.8	0.0	2.9
November 13	21.5	19.8	15.4	0.8	3.8
November 14	20.9	15.8	10.6	1.5	3.8
November 15	25.6	22.5	16.0	1.6	5.3
November 16					
November 17	33.3	27.6	20.5	2.4	2.4
November 18	24.9	20.2	17.6	2.5	5.5

TABLE CXXIV.—*Average daily evaporation in different situations near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Date.	Top of a tall tree in second-growth forest.	Lawn.	In small patch of *Saccharum*.		Near ground under second-growth forest.
			At top of grass.	On ground under grass.	
1913.					
November 19	19.5	16.7	13.4	2.7	6.3
November 20	0.0	0.0	0.0	0.0	0.0
November 21	11.4	8.5	4.5	0.0	0.0
November 22	14.3	11.6	6.6	0.0	0.0
November 23	9.4	5.4	1.0	0.5	0.5
November 24	19.8	17.6	10.6	1.2	4.9
November 25	18.1	14.1	8.3	0.8	3.0
November 26	22.3	19.2	13.8	1.7	4.3
November 27	26.8	20.8	18.1	2.7	5.6
November 28	1.8	0.0	0.0	0.0	0.0
November 29	16.7	10.1	10.2	0.0	0.0
November 30					
December 1	30.8	19.5	16.6	1.7	6.2
December 2	23.1	14.5	13.0	1.0	3.8
December 3	16.9	11.3	11.6	2.2	3.1
December 4	21.2	14.6	14.5	2.3	4.1
December 5	14.5	10.3	9.1	0.0	1.8
December 6	8.5	5.9	4.5	0.7	0.9
December 7	9.3	6.2	5.6	0.0	1.0
December 8	19.1	13.1	10.3	0.9	2.4
December 9	10.5	7.4	4.5	0.0	0.8
December 10	14.9	10.7	7.2	0.0	2.1
December 11	21.4	15.1	11.7	0.0	4.1
December 12	13.8	10.4	8.6	1.9	1.7
December 13	17.9	12.8	11.5	1.3	3.0
December 14	10.6	7.1	4.6	0.0	1.1
December 15	5.3	3.3	2.4	0.0	0.0
December 16	4.5	3.4	1.4	0.0	0.0
December 17	18.0	12.3	10.1	0.0	2.3
December 18	13.2	9.6	6.9	0.0	1.2
December 19	3.3	2.4	2.0	0.0	0.0
December 20	6.9	5.5	4.9	0.0	0.0
December 21	11.6	9.2	6.0	0.6	1.2
December 22	14.4	9.5	7.3	0.9	2.6
December 23	15.1	11.2	9.9	1.0	3.1
December 24	13.1	9.7	9.0	0.7	2.7
December 25					
December 26	28.4	20.1	15.9	1.6	4.4
December 27	27.1	19.6	20.0	6.8	4.9
December 28					
December 29	32.9	20.2	19.3	5.2	6.5
December 30	15.7	13.8	11.0	3.1	3.3
December 31	12.4	9.4	6.1	0.8	2.8
1914.					
January 1	16.1	14.2	9.2	3.0	4.0
January 2	16.1	12.7	9.7	3.7	4.1
January 3	13.3	12.3	7.6	1.9	3.1

TABLE CXXIV.—*Average daily evaporation in different situations near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Date.	Top of a tall tree in second-growth forest.	Lawn.	In small patch of *Saccharum*. At top of grass.	In small patch of *Saccharum*. On ground under grass.	Near ground under second-growth forest.
1914.					
January 4	8.3	6.8	2.8	0.0	1.0
January 5	15.8	12.2	8.9	1.9	2.9
January 6	19.9	16.1	13.7	4.4	4.6
January 7	20.5	14.9	13.7	3.1	3.7
January 8	21.0	15.8	18.7	3.1	5.4
January 9	11.0	9.3	5.2	0.0	1.7
January 10	34.1	27.5	18.4	5.6	8.9
January 11	20.0	12.7	10.4	3.9	5.3
January 12	19.7	16.9	13.0	4.6	5.5
January 13	20.4	17.3	13.1	4.2	5.2
January 14	14.8	11.9	8.9	2.6	4.3
January 15	17.6	12.6	9.8	2.9	3.3
January 16	19.9	17.3	12.8	4.7	6.1
January 17	32.8	27.1	20.2	5.6	7.4
January 18					
January 19	50.2	40.0	33.3	11.2	16.4
January 20	16.8	14.4	11.4	4.3	5.0
January 21	20.9	17.8	13.4	3.5	5.5
January 22	21.8	18.4	14.0	4.1	6.9
January 23	10.9	10.1	5.8	1.4	2.0
January 24	11.8	10.3	5.8	5.9	1.8
January 25	19.0	16.6	12.4	3.2	4.4
January 26					
January 27	40.0	39.1	35.8	9.9	16.3
January 28					
January 29	40.0	37.2	29.6	10.5	16.2
January 30	21.1	17.7	14.0	4.2	5.9
January 31	29.9	21.4	17.4	5.7	7.6
February 1	23.3	21.4	14.7	4.4	7.1
February 2	25.5	23.8	19.3	6.6	8.6
February 3	21.9	19.8	13.8	4.1	6.4
February 4	22.0	21.2	15.3	5.4	7.5
February 5	12.3	9.1	5.7	1.4	2.3
February 6	24.9	22.1	16.7	3.3	6.3
February 7	26.7	24.0	18.1	5.9	9.0
February 8					
February 9	45.5	41.4	30.9	8.5	15.5
February 10	20.1	19.0	13.5	4.9	6.9
February 11	13.5	14.3	10.0	3.8	4.6
February 12	20.7	19.6	13.2	3.5	7.0
February 13	12.4	10.2	6.3	1.2	2.9
February 14	13.4	14.5	9.6	2.3	3.5
February 15	19.2	17.3	11.1	3.2	5.5
February 16	29.7	26.2	19.5	6.8	10.7
February 17	35.8	33.1	23.7	9.1	13.9
February 18	20.9	18.9	15.6	5.5	7.6
February 19	33.1	31.5	22.8	9.5	12.3

TABLE CXXIV.—*Average daily evaporation in different situations near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Date.	Top of a tall tree in second-growth forest.	Lawn.	In small patch of *Saccharum*. At top of grass.	In small patch of *Saccharum*. On ground under grass.	Near ground under second-growth forest.
1914.					
February 20	29.0	26.1	19.7	7.2	6.6
February 21	41.7	30.5	22.6	9.8	12.8
February 22					
February 23	60.7	57.3	42.3	18.0	25.1
February 24	22.8	22.8	19.0	6.0	8.7
February 25	25.9	24.1	18.9	7.4	9.9
February 26	33.1	30.6	24.3	10.8	13.3
February 27	13.7	11.7	8.7	3.0	4.4
February 28	31.3	23.6	21.2	7.5	10.1
March 1					
March 2	46.6	44.3	32.1	13.2	18.6
March 3	23.0	19.6	13.7	5.3	8.8
March 4	36.1	35.5	24.3	12.1	14.5
March 5	21.9	22.1	15.8	7.1	8.8
March 6	22.9	21.1	16.0	5.9	9.5
March 7	32.7	28.9	27.6	12.4	13.1
March 8	25.7	26.9	21.7	9.7	10.9
March 9	21.2	22.3	15.7	6.5	8.8
March 10	28.5	28.9	22.2	9.5	13.1
March 11	32.1	33.2	24.3	13.6	15.3
March 12	32.9	35.1	27.4	12.7	17.2
March 13	32.5	34.1	26.8	14.2	18.2
March 14	36.9	36.5	21.0	14.5	17.5
March 15					
March 16	53.9	56.6	42.4	18.3	27.4
March 17	31.7	32.6	21.1	10.4	11.2
March 18	25.7	27.9	19.5	10.9	11.3
March 19	32.7	35.8	25.8	14.5	15.7
March 20	38.9	43.4	30.5	13.9	20.4
March 21	28.7	36.3	23.7	12.4	17.2
March 22	36.7	40.8	30.4	15.1	20.4
March 23	27.9	33.3	23.4	12.8	16.0
March 24	33.4	38.0	27.0	14.5	19.0
March 25	29.5	33.9	23.8	11.6	18.2
March 26	38.2	44.1	31.0	16.8	22.6
March 27	25.4	28.6	19.5	13.3	13.8
March 28	29.1	32.4	23.2	9.9	14.2
March 29					
March 30	75.0	88.1	62.7	30.5	46.0
March 31	28.9	33.2	24.1	13.9	17.9
April 1	32.7	40.2	29.2	14.5	21.2
April 2	30.5	35.5	24.9	12.2	18.2
April 3	35.7	46.6	31.2	16.8	20.4
April 4	21.3	26.2	17.2	12.0	11.3
April 5					
April 6	32.3	40.5	30.3	13.2	20.0
April 7	22.5	28.1	20.2	10.0	13.8

TABLE CXXIV.—*Average daily evaporation in different situations near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Date.	Top of a tall tree in second-growth forest.	Lawn.	In small patch of *Saccharum*. At top of grass.	In small patch of *Saccharum*. On ground under grass.	Near ground under second-growth forest.
1914.					
April 8	23.1	30.2	25.1	11.7	17.5
April 9	22.2	35.6	25.0	14.3	18.0
April 10	10.9	9.6	8.5	2.5	4.4
April 11	21.2	24.4	18.7	7.7	10.2
April 12	29.6	37.0	28.8	13.7	19.0
April 13	28.9	34.9	26.2	12.8	18.2
April 14	17.4	22.0	16.5	7.4	11.7
April 15	24.1	27.1	23.8	8.1	21.4
April 16	16.9	17.1	14.8	5.8	8.8
April 17	27.3	28.7	23.7	10.3	14.6
April 18	26.2	28.6	22.3	10.8	15.3
April 19					
April 20	59.7	62.6	49.2	24.5	31.7
April 21	15.6	18.3	11.9	3.1	4.4
April 22	30.3	31.8	22.7	9.8	13.0
April 23	9.4	9.2	5.6	2.2	2.3
April 24	31.1	31.0	28.0		18.1
April 25	31.0	33.9	32.5		19.2
April 26					
April 27	54.7	56.8	48.6		24.8
April 28	36.3	34.4	29.5		14.2
April 29	33.4	34.4	34.6		15.3
April 30	33.5	34.9	28.4		14.8
May 1	36.9	38.5			20.4
May 2	41.0	43.8			19.7
May 3	34.8	41.4			17.1
May 4	38.8	42.0			16.8
May 5	31.6	36.3			13.1
May 6	31.7	37.7			16.0
May 7	38.7	43.0			19.7
May 8	32.1	37.6			15.3
May 9	28.2	33.8			13.1
May 10	37.6	31.5			13.8
May 11	16.6	17.7			6.6
May 12	22.3	23.0			8.7
May 13	35.5	37.6			13.1
May 14	38.2	41.9			16.4
May 15	40.7	44.5			16.7
May 16	33.8	39.7			15.0
May 17	27.6	28.8			12.5
May 18	33.2	39.5			15.3
May 19	27.3	31.3			13.1
May 20	20.2	26.8			9.9
May 21	12.9	15.3			2.5
May 22	14.5	16.3			3.6
May 23	28.1	27.8			8.0
May 24					

TABLE CXXIV.—*Average daily evaporation in different situations near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Date.	Top of a tall tree in second-growth forest.	Lawn.	In small patch of *Saccharum*.		Near ground under second-growth forest.
			At top of grass.	On ground under grass.	
1914.					
May 25	64.2	68.1			23.0
May 26	36.7	37.0			13.5
May 27	25.3	29.1			9.5
May 28	34.6	36.4			12.4
May 29	23.6	29.8			9.5
May 30	20.9	23.3			8.4
May 31					
June 1	48.6	51.2			15.3
June 2	13.4	15.0			4.4
June 3	2.0	2.2			0.0
June 4	3.3	1.3			0.0
June 5	23.6	20.6			5.1
June 6	28.3	27.3			8.0
June 7	22.6	21.1			5.8
June 8	27.2	26.1			9.5
June 9	24.0	23.9			5.4
June 10	24.2	24.5			8.0
June 11	32.8	31.6			8.0
June 12	24.4	26.5			5.8
June 13	28.5	21.3			4.4
June 14	19.7	17.5			4.4
June 15	26.3	26.4			6.9
June 16	33.1	35.0			10.9
June 17	9.6	8.8			2.5
June 18	24.5	24.6			5.8
June 19	5.7	4.2			0.0
June 20	0.0	0.0			0.0
June 21					
June 22	7.5	13.3			2.2
June 23	14.5	13.1			1.5
June 24	24.6	22.4			4.9
June 25	17.8	16.5			3.0
June 26	20.4	18.4			6.5
June 27	17.6	17.1			5.1
June 28	18.1	17.6			5.1
June 29	19.0	18.6			4.7
June 30	17.1	15.8			4.4
July 1	19.1	18.1			5.5
July 2	13.2	13.2			3.1
July 3	15.8	16.1			3.9
July 4	11.8	12.2			2.0
July 5					
July 6	18.2	16.1			0.8
July 7	14.0	12.2			2.4
July 8	19.4	16.5			1.2
July 9	19.5	26.0			6.3
July 10	40.9	32.9			9.5

TABLE CXXIV.—*Average daily evaporation in different situations near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Date.	Top of a tall tree in second-growth forest.	Lawn.	In small patch of *Saccharum*. At top of grass.	In small patch of *Saccharum*. On ground under grass.	Near ground under second-growth forest.
1914.					
July 11	40.2	39.7			12.6
July 12					
July 13	88.8	92.2			33.1
July 14	41.4	44.3			15.8
July 15	27.9	33.1			10.2
July 16	10.1	11.2			3.1
July 17	8.7	7.6			0.0
July 18	8.4	8.1			0.0
July 19	15.9	15.8			2.7
July 20	11.4	9.9			0.0
July 21	12.2	10.7			1.2
July 22	13.4	10.2			2.4
July 23	9.4	9.1			1.7
July 24	8.1	11.3			0.0
July 25	7.3	6.4			1.6
July 26	15.6	15.5			1.6
July 27	19.5	18.5			5.5
July 28	16.6	15.3			2.4
July 29	19.8	17.7			3.9
July 30	22.3	21.6			4.7
July 31	17.4	15.2			2.4
August 1	19.9	18.5			5.5
August 2	22.	22.2			7.1
August 3	20.7	21.2			6.3
August 4	18.6	17.6			5.5
August 5	28.2	26.5			9.5
August 6	20.7	22.8			7.9
August 7	18.5	19.3			5.5
August 8	18.3	18.2			4.7
August 9					
August 10	17.9	16.3			1.6
August 11	5.1	4.7			0.0
August 12					
August 13	34.4	35.2			7.9
August 14	10.7	9.6			0.0
August 15	23.2	19.4			4.7
August 16	20.6	20.3			4.7
August 17	20.8	20.4			6.3
August 18	14.5	14.2			3.9
August 19	20.0	16.3			2.4
August 20	9.9	10.3			1.6
August 21	31.4	25.3			6.3
August 22	24.0	23.2			5.1
August 23	11.3	11.5			0.8
August 24	26.0	25.0			7.9
August 25	41.1	20.5			11.8
August 26	51.0	51.6			16.6

TABLE CXXIV.—*Average daily evaporation in different situations near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Date.	Top of a tall tree in second-growth forest.	Lawn.	In small patch of *Saccharum*.		Near ground under second-growth forest.
			At top of grass.	On ground under grass.	
1914.					
August 27	50.9	50.0			17.4
August 28	50.4	52.1			17.4
August 29	34.4	34.3			7.9
August 30					
August 31	59.8	61.3			16.6
September 1	11.6	11.0			3.9
September 2	2.3	2.9			0.0
September 3	3.1	3.0			0.0
September 4	0.0	0.0			0.0
September 5	3.1	1.6			0.0
September 6	9.5	8.6			1.6
September 7	19.9	19.3			2.4
September 8	7.5	7.4			0.0
September 9	1.0	2.8			0.0
September 10	5.4	4.4			0.0
September 11	26.6	26.0			7.9
September 12	29.0	30.1			6.3
September 13	4.3	3.3			0.0
September 14	8.1	7.2			1.2
September 15	13.5	11.3			1.6
September 16	17.7	14.8			4.7
September 17	13.2	11.3			2.4
September 18	15.8	12.0			3.1
September 19	21.4	19.6			4.7
September 20	22.2	19.6			5.5
September 21	21.0	19.8			3.9
September 22	20.6	19.0			4.7
September 23	17.5	17.3			5.5
September 24	24.8	22.3			5.5
September 25	17.6	15.6			3.9
September 26	17.2	15.9			3.9
September 27	11.8	12.1			1.6
September 28	15.7	13.8			2.4
September 29	9.0	8.0			2.4
September 30	10.5	8.3			0.0
October 1	12.1	9.7			1.6
October 2	18.1	16.9			3.1
October 3	21.1	18.6			4.7
October 4					
October 5	29.2	24.9			3.9
October 6	23.7	20.2			4.3
October 7	13.7	10.5			3.1
October 8	8.6	6.4			0.0
October 9	18.6	14.0			2.0
October 10	19.3	15.1			3.1
October 11	22.7	18.9			3.9
October 12	21.3	19.5			4.7

TABLE CXXIV.—*Average daily evaporation in different situations near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Date.	Top of a tall tree in second-growth forest.	Lawn.	In small patch of *Saccharum*. At top of grass.	In small patch of *Saccharum*. On ground under grass.	Near ground under second-growth forest.
1914.					
October 13	22.5	17.9	----------	----------	3.9
October 14	23.6	22.2	----------	----------	6.7
October 15	21.9	17.9	----------	----------	5.9
October 16	16.9	14.4	----------	----------	4.7
October 17	14.0	12.6	----------	----------	4.7
October 18	----------	----------	----------	----------	----------
October 19	24.7	22.3	----------	----------	3.9
October 20	10.7	10.3	----------	----------	1.6
October 21	21.3	17.7	----------	----------	3.1
October 22	14.7	13.2	----------	----------	3.1
October 23	21.3	16.7	----------	----------	1.6
October 24	28.4	26.0	----------	----------	7.1
October 25	----------	----------	----------	----------	----------
October 26	39.3	35.2	----------	----------	6.3
October 27	25.1	20.6	----------	----------	4.7
October 28	21.1	19.2	----------	----------	1.6
October 29	12.6	10.8	----------	----------	2.4
October 30	19.8	16.7	----------	----------	3.9
October 31	29.4	26.9	----------	----------	3.5
November 1	24.4	24.0	----------	----------	3.0
November 2	14.5	14.3	----------	----------	3.1
November 3	25.0	34.5	----------	----------	3.9
November 4	21.3	19.9	----------	----------	4.7
November 5	19.1	17.6	----------	----------	4.7
November 6	16.8	20.5	----------	----------	3.1
November 7	17.2	17.4	----------	----------	3.9
November 8	----------	----------	----------	----------	----------
November 9	25.4	21.5	----------	----------	3.9
November 10	20.8	19.2	----------	----------	2.4
November 11	26.1	25.4	----------	----------	7.1
November 12	23.3	20.3	----------	----------	3.1
November 13	18.0	17.7	----------	----------	3.9
November 14	23.4	22.3	----------	----------	3.9
November 15	----------	----------	----------	----------	3.9
November 16	42.0	38.6	----------	----------	3.9
November 17	14.0	14.0	----------	----------	4.6
November 18	16.9	15.1	----------	----------	5.5
November 19	22.1	19.9	----------	----------	6.3
November 20	16.0	14.5	----------	----------	5.5
November 21	17.7	18.1	----------	----------	6.5
November 22	----------	----------	----------	----------	----------
November 23	44.0	42.5	----------	----------	7.1
November 24	16.0	14.0	----------	----------	4.7
November 25	20.8	22.1	----------	----------	6.2
November 26	12.1	23.5	----------	----------	7.9
November 27	15.0	15.9	----------	----------	4.7
November 28	14.8	10.8	----------	----------	0.0

TABLE CXXIV.—*Average daily evaporation in different situations near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Date.	Top of a tall tree in second-growth forest.	Lawn.	In small patch of *Saccharum*. At top of grass.	In small patch of *Saccharum*. On ground under grass.	Near ground under second-growth forest.
1914.					
November 29	14.3	10.7			0.8
November 30	8.8	8.8			0.0
December 1	6.8	7.2			1.6
December 2	10.8	10.2			0.0
December 3	9.1	8.5			0.6
December 4	15.3	16.0			1.6
December 5	11.3	10.2			0.8
December 6	10.8	10.3			1.7
December 7	17.1	15.3			3.3
December 8	19.5	17.2			3.9
December 9	10.4	8.1			1.6
December 10	7.9	6.1			0.0
December 11	17.7	15.9			3.1
December 12	12.6	11.5			1.6
December 13	7.1	5.1			1.6
December 14	15.5	13.2			2.2
December 15	21.3	19.5			4.7
December 16	13.6	12.7			3.1
December 17	10.9	9.8			3.1
December 18	23.0	19.2			5.5
December 19	23.3	18.7			5.5
December 20	17.9	15.8			6.3
December 21	11.5	10.7			3.1
December 22	15.4	13.0			3.1
December 23	13.1	12.0			4.7
December 24	20.5	19.0			7.1
December 25	7.1	5.7			1.6
December 26	13.7	11.0			2.4
December 27					
December 28	45.8	39.7			12.6
December 29	26.6	21.6			7.1
December 30	22.1	19.9			7.9
December 31	12.5	10.5			1.6
1915.					
January 1	22.5	19.6			6.3

lawn showed no evaporation. On October 12, 1913, when there was an evaporation of 1.8 cubic centimeters in the top of the second-growth tree, there was no evaporation from the instrument in the lawn.

From Table CXXV it will be seen very clearly that the highest average rates of evaporation occur during the dry season. The highest average rates for four-week periods occurred

TABLE CXXV.—*Daily evaporation for periods of four weeks from July, 1913, to January, 1915, in different situations near the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Four weeks ending—	Top of tall tree in second-growth forest.			In lawn.		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
January 30	19.3	34.1	8.3	16.2	27.5	6.8
February 27	24.2	41.7	12.3	21.2	33.1	9.1
March 27	29.6	38.9	21.2	30.8	44.1	19.6
April 24	25.1	37.5	9.4	29.2	46.6	9.2
May 22	30.8	41.0	12.9	33.7	44.5	15.3
June 19	23.4	36.7	2.0	23.6	37.0	1.3
July 17	18.2	44.4	0.0	15.8	46.1	0.0
August 14	16.7	41.9	4.1	13.3	32.6	1.4
September 11	19.9	51.0	0.0	16.3	52.1	0.0
October 9	17.9	35.5	4.3	14.6	30.1	2.6
November 6	18.4	31.6	1.8	15.5	34.5	0.0
December 4	16.5	26.8	0.0	14.3	25.4	0.0
January 1	14.9	27.1	3.3	11.9	21.6	2.4
Average	21.1	37.6	6.1	19.7	36.6	5.2

between January 30 and June 19, and particularly during March, April, and May. After June the rates were very much lower than during the dry season and reached the minimum in December. The high rates in the dry season are probably the result of the combined action of intense light, low humidity, and high wind velocity; while the lowest rates occur at the time when the temperature is lowest and the humidity greatest. The highest minimum daily rates also occur in the dry season; and the lowest, during the latter part of the year. The maximum daily rates, however, bear no such relation to the alternating dry and wet seasons as do the average and the minimum rates. The absolute maximum in both cases occurred during the last week of August, 1914, which is during the middle of the rainy season. Moreover, the maximum daily rates in the top of the tree for the four weeks ending July 17, August 14, and September 11, respectively, are all higher than any of the maximum rates for the dry season. These high rates were observed to be coincident with high wind velocity during typhoon periods, when there was little or no rain. Despite the fact that these very high rates are found during the rainy or typhoon season, the average rates at this time are much lower than during the dry season.

TABLE CXXVI.—*Daily evaporation for periods of four weeks from July, 1913, to January, 1915, near the ground under the second-growth forest near the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Four weeks ending—	Average.	Maximum.	Minimum.
January 30	5.3	8.9	1.0
February 27	8.1	13.9	2.3
March 27	14.2	22.6	8.8
April 24	14.7	23.0	2.3
May 22	13.8	20.4	2.5
June 19	6.9	13.5	0.0
July 17	4.5	16.6	0.0
August 14	2.6	9.5	0.0
September 11	3.8	17.4	0.0
October 9	2.8	6.3	0.0
November 6	3.3	7.1	0.0
December 4	3.0	7.9	0.0
January 1	3.0	7.9	0.0
Average	6.6	13.5	1.3

The rates of evaporation under the second-growth trees are given in Table CXXVI. It will be seen that the average daily evaporation is 6.6 cubic centimeters, which is only 31 per cent of the rate in the top of the tree. The maximum daily evaporation was 23 cubic centimeters, which is less than half the maximum rate either in the top of the second-story tree or in the lawn. The minimum rate was 0.0 and occurred during all the four-week periods beginning with the one ending June 19 and terminating with that ending January 1. The maximum daily evaporation occurred in the dry season and not in the rainy, as did the maximum in the second-growth tree and in the lawn. This is very probably due to the fact that the atmometer under the trees was protected to a considerable extent from the winds that caused these very high rates in the other two situations. The highest average and the highest maximum and minimum under the trees are all found to occur during the dry season when humidity is lowest.

The rates of evaporation for a small grass area are given in Table CXXVII. The average daily evaporation in the top of the grass was 13.5 cubic centimeters. This indicates that the tops of the grass cut down the evaporation found in the lawn by 31 per cent. The maximum at the top of the grass was 31.4 cubic centimeters and the minimum, as might be expected, 0.0. The average daily evaporation under the grass was 4 cubic centimeters, which is 61 per cent of that under the forest

and 19 per cent of that in the top of the second-growth tree. That the rate under the grass is less than under the trees is probably due to the fact that the grass lessened the movement of the wind more than did the second-growth forest. The maximum under the grass was 16.8 cubic centimeters, and the minimum, 0.0.

TABLE CXXVII.—*Daily evaporation for periods of four weeks from July, 1913, to January, 1915, in a small patch of Saccharum near the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Four weeks ending—	At top of grass.			Near ground under grass.		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
January 30	12.6	20.2	2.8	3.8	5.9	0.0
February 27	16.2	24.3	5.7	5.6	10.8	1.2
March 27	22.4	31.0	13.7	11.0	16.8	5.3
April 24	21.9	31.4	5.6	9.9	16.8	2.2
July 17	10.1	21.7	1.1	1.4	4.4	0.0
August 14	10.7	29.9	0.7	2.0	8.1	0.0
September 11	12.0	25.6	0.4	2.8	8.4	0.0
October 9	13.3	22.9	1.3	2.7	9.0	0.0
November 6	11.7	21.0	0.0	2.3	5.8	0.0
December 4	9.3	18.1	0.0	1.0	2.7	0.0
January 1	7.9	20.0	1.4	1.2	6.8	0.0
Average	13.5	24.2	3.0	4.0	8.7	0.8

In addition to daily readings the rate of evaporation was also measured weekly in the top of the second-growth tree and under the second-growth forest from November 22, 1912, until July, 1913. Weekly readings were also taken in the crown of a second-growth tree, at the top of a large area of *Saccharum spontaneum*, and near the ground under the *Saccharum*.

The weekly results in these five situations for the period from November 22, 1912, to January 1, 1915, are given in Table CXXVIII, and summarized for corresponding four-week periods in Table CXXIX. The average rate of evaporation in the top of the second-growth tree for the entire period is very similar to that for the shorter period previously discussed. Near the ground under the second-growth forest the rate of evaporation for the longer period was slightly lower than for the shorter one. The rate in the crown of the second-growth tree was intermediate between that under the forest and that in the top of the tree, but was much nearer the rate under the tree than that in the top. The average daily rate in the top of the tree

TABLE CXXVIII.—*Average daily evaporation for weekly periods in different situations near the base of Mount Maquiling; altitude, about 100 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Week ending—	Top of second-growth tree.	In second-growth tree.	Under second-growth tree.	Grass area. (*Saccharum spontaneum.*)	
				Top of grass.	Under grass.
1912.					
November 22	22.0	6.9	------	10.3	------
November 29	20.0	6.3	3.1	8.4	------
December 6	18.0	6.4	1.8	9.3	------
December 13	20.7	7.5	2.8	9.6	1.2
December 20	21.1	7.1	2.2	10.2	2.3
December 27	18.9	6.4	1.4	9.2	1.1
1913.					
January 3	11.2	4.1	0.7	1.1	0.8
January 10	17.9	5.3	1.9	8.5	1.5
January 17	18.1	5.5	1.8	7.1	1.4
January 24	22.9	7.0	4.1	10.3	2.9
January 31	21.2	6.0	2.7	2.7	1.5
February 7	27.2	9.0	3.8	9.5	3.6
February 14	30.1	10.2	5.3	12.9	4.1
February 21	26.1	9.2	5.4	12.5	4.3
February 28	23.8	8.9	4.9	14.2	5.5
March 7	19.2	7.8	2.6	12.1	11.0
March 14	25.2	11.0	6.0	14.2	5.1
March 21	35.3	17.4	12.9	23.5	20.3
March 28	31.2	14.6	12.2	22.2	12.3
April 4	30.8	19.0	15.1	20.1	10.3
April 11	32.0	18.4	8.6	13.1	10.5
April 18	18.9	9.3	5.4	7.7	3.9
April 25	28.6	13.0	8.8	12.8	6.9
May 2	36.6	19.4	12.5	12.7	11.3
May 9	18.0	7.9	1.7	4.6	0.5
May 16	27.3	11.2	8.2	13.4	6.5
May 23	28.6	11.7	7.1	15.0	6.0
May 30	23.6	6.7	6.0	14.2	4.2
June 6	33.6	14.7	11.2	17.1	7.6
June 13	36.6	16.9	14.7	21.6	9.6
June 20	27.7	12.6	6.1	16.2	5.1
June 27	21.7	7.8	4.2	11.2	4.1
July 4	18.3	8.8	6.7	10.7	2.4
July 11	17.9	5.9	3.1	9.3	1.6
July 18	10.7	3.5	1.5	6.8	1.6
July 25	14.3	5.8	1.0	8.2	0.4
August 1	18.2	6.1	1.3	8.7	0.7
August 8	15.3	5.6	1.6	8.4	0.0
August 15	23.4	10.0	3.7	13.1	0.0
August 22	18.1	7.0	2.6	10.3	0.0
August 29	14.6	4.7	1.5	7.8	0.0
September 5	22.0	7.6	2.5	8.9	0.0
September 12	21.8	8.8	2.6	12.8	0.2
September 19	22.6	8.5	3.0	15.4	0.9

TABLE CXXVIII.—*Average daily evaporation for weekly periods in different situations near the base of Mount Maquiling; altitude, about 100 meters*—Continued.

Week ending—	Top of second-growth tree.	In second-growth tree.	Under second-growth tree.	Grass area. (*Saccharum spontaneum.*) Top of grass.	Under grass.
1913.					
September 26	17.2	5.3	1.9	12.1	0.0
October 3	20.6	6.1	2.6	11.6	2.5
October 10	17.7	5.3	2.1	10.6	2.1
October 17	9.5	6.9	1.1	3.3	0.8
October 24	20.5	7.2	3.2	11.2	2.4
October 31	26.2	9.0	5.1	12.4	4.9
November 7	12.3	4.3	1.8	6.1	2.1
November 14	14.2	5.7	1.5	5.5	1.1
November 21	16.4	6.9	2.8	5.8	2.8
November 28	16.1	6.1	2.6	5.5	1.4
December 5	17.6	6.0	2.7	6.2	1.0
December 12	13.9	4.9	1.9	6.4	0.7
December 19	10.4	3.6	1.1	3.6	0.6
December 26	12.8	4.0	2.0	6.0	0.6
1914.					
January 2	17.2	5.8	3.6	6.0	1.5
January 9	15.7	5.3	3.2	6.7	1.7
January 16	20.9	6.9	5.5	9.1	2.6
January 23	21.9	7.4	6.2	10.6	4.2
January 30	18.8	8.0	6.4	10.1	3.7
February 6	22.8	8.0	6.5	6.7	4.4
February 13	19.8	7.9	6.6	10.1	4.5
February 20	25.9	10.4	8.6	13.8	6.4
February 27	28.3	10.9	10.6	14.9	7.2
March 6	26.0	10.5	10.0	16.6	6.4
March 13	29.4	13.4	13.8	19.7	9.2
March 20	31.4	15.9	14.8	20.3	10.0
March 27	31.4	17.0	18.2	20.9	11.8
April 3	33.1	18.4	19.7	22.6	----------
April 10	18.9	10.9	12.1	13.9	----------
April 17	23.6	13.0	14.8	19.4	----------
April 24	24.6	12.6	12.1	20.9	----------
May 1	32.3	15.9	15.5	24.9	----------
May 8	35.5	18.4	16.8	26.9	----------
May 15	31.3	14.4	12.6	22.4	----------
May 22	24.2	12.6	10.3	18.4	----------
May 29	30.4	14.4	10.8	15.4	----------
June 5	16.0	8.2	4.7	11.5	----------
June 12	26.2	11.7	7.2	19.3	----------
June 19	21.1	9.2	5.0	13.0	----------
June 26	12.1	5.6	2.6	9.1	----------
July 3	17.1	8.6	4.3	14.1	----------
July 10	17.7	8.9	3.2	10.8	----------
July 17	31.0	16.1	10.2	23.7	----------
July 24	11.3	5.0	1.1	8.0	----------
July 31	16.9	8.9	3.2	11.6	----------

TABLE CXXVIII.—*Average daily evaporation for weekly periods in different situations near the base of Mount Maquiling; altitude, about 100 meters*—Continued.

Week ending—	Top of second-growth tree.	In second-growth tree.	Under second-growth tree.	Grass area. (*Saccharum spontaneum.*) Top of grass.	Under grass.
1914.					
August 7	21.3	12.0	6.8	18.0	9.0
August 14	12.3	6.3	2.0	5.9	0.6
August 21	20.1	9.6	4.3	12.4	2.9
August 28	36.4	18.7	11.0	21.9	6.9
September 4	15.9	8.6	4.1	9.4	1.5
September 11	10.4	5.9	1.7	4.4	0.2
September 18	14.5	6.6	2.8	7.9	1.3
September 25	20.7	9.1	4.8	14.6	4.2
October 2	13.5	5.4	2.1	8.3	1.6
October 9	16.4	6.9	2.6	8.5	1.1
October 16	21.2	8.1	4.7	11.2	2.5
October 23	15.2	5.7	2.6	6.7	0.4
October 30	20.9	7.4	3.7	9.4	1.8
November 6	21.5	7.6	3.7	10.7	2.7
November 13	18.7	6.9	3.5	9.1	1.7
November 20	19.2	6.7	4.8	9.6	2.7
November 27	17.9	7.6	5.3	9.9	3.2
December 4	11.4	4.3	0.7	4.1	0.2
December 11	13.5	5.0	2.1	7.3	0.6
December 18	14.9	5.9	3.1	7.9	1.6
December 25	15.5	6.4	4.5	9.3	1.9
1915.					
January 1	20.5	7.9	5.4	11.3	2.3

was 21.6 cubic centimeters; in the crown of the second-growth tree, 9.2 cubic centimeters; and under the forest, 5.8 cubic centimeters. The rates of evaporation in the large grass area are very similar to those in the smaller area. The average daily rate at the top of the grass in the large area was 12.1 cubic centimeters, and in the smaller, 13.5 cubic centimeters. This difference may be accounted for by the fact that the grass in the smaller area did not interfere as much with the wind movement as did the grass in the large space. The rates under the grass are practically the same in the two cases, being 4 cubic centimeters in the small patch and 3.9 cubic centimeters in the large one.

Yapp * measured the rate of evaporation at different eleva-

* Yapp, R. H., On stratification in the vegetation of a marsh, and its relations to evaporation and temperature, *Ann. Bot.* (1909), 23, 275–319.

tions in a sedge marsh and found that above the sedge it was more than fifteen times that in the lowest stratum.

TABLE CXXIX.—*Average daily evaporation for periods of four weeks from November, 1912, to January, 1915, in different situations near the base of Mount Maquiling; altitude, about 100 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Four weeks ending—	Top of second-growth tree.	In second-growth tree.	Under second-growth forest.	Grass area. (*Saccharum spontaneum.*) Top of grass.	Grass area. (*Saccharum spontaneum.*) Under grass.
January 31	19.7	6.5	4.0	8.2	2.5
February 28	25.5	9.3	6.5	11.9	5.0
March 28	28.7	13.5	11.3	18.7	10.8
April 25	26.4	14.3	12.1	16.3	7.9
May 23	29.2	14.0	10.6	17.3	6.1
June 20	26.9	11.8	8.2	16.1	6.6
July 18	18.4	8.2	4.5	12.0	2.4
August 15	16.7	7.5	2.6	10.3	0.3
September 12	19.9	8.9	3.8	11.0	1.5
October 10	17.9	6.7	2.8	11.1	1.8
November 7	18.4	7.1	3.3	8.9	2.3
December 5	17.7	6.4	2.8	7.8	1.8
January 2	15.9	5.7	2.6	7.3	1.3
Average	21.6	9.2	5.8	12.1	3.9

Dachnowski * has measured the rates of evaporation at different heights in an Ohio bog and found that the evaporation at 5 feet above the ground was twice that at 3 inches above the soil.

Sherff † observed similar conditions in a bog in Illinois, where he found that evaporation was ten times as great 175 centimeters above the soil as at its surface.

Dachnowski's figures for evaporation near the ground and at greater heights do not differ so much as do those in the grass areas on Mount Maquiling, but the differences found by Sherff and Yapp are greater than those at the base of Mount Maquiling. This may well be due to the fact that the substrata are moister in the marsh and bog than in the grass area.

In fig. 20 are plotted the rates of evaporation for four-week periods at the top of the second-growth tree, in the crown of

* Dachnowski, A., The vegetation of Cranberry Island (Ohio) and its relations to the substratum, temperature, and evaporation. II, *Bot. Gaz.* (1911), **52**, 126–150.

† Sherff, E. E., Evaporation conditions at Skokie marsh, *Plant World* (1913), **16**, 154–160.

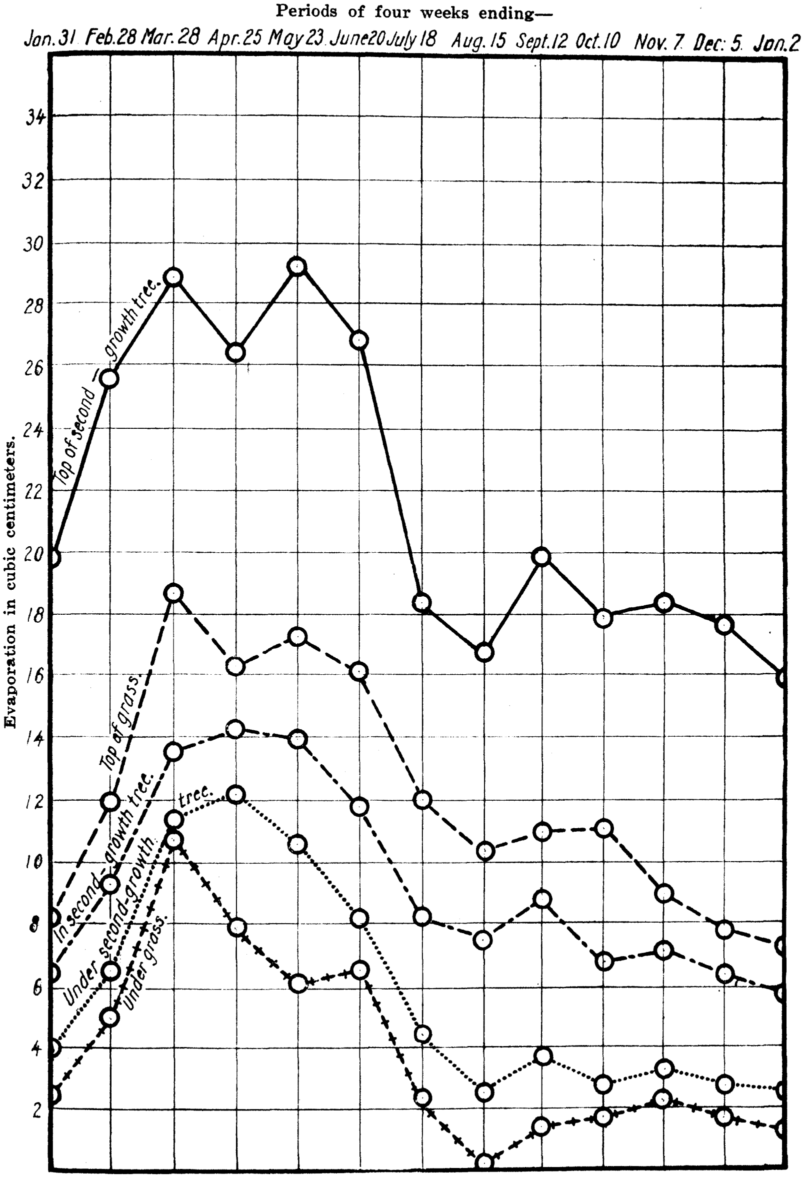

FIG. 20. Average daily evaporation in different situations near the base of Mount Maquiling; altitude, about 100 meters.

the second-growth tree, under the second-growth tree, at the top of the grass, and under the grass. All of these curves have approximately the same form and show clearly the high rate of evaporation during the dry season. After the dry season, which is most pronounced during March and April, there was a rapid

fall in the rate of evaporation until the four-week period ending July 18, after which there was a slight rise followed by another fall, the lowest rate in every case occurring during the four weeks ending January 2. The greater difference between the rate in the top of the tree and that in the tree than between the rate in the tree and that under the trees is emphasized. At the top of the grass, as might be expected, the rate during every period is shown to be next to that in the top of the tree. The rate for every period is less under the grass than under the trees.

Table CXXX gives the weekly evaporation in the lawn and on the bare ground in an area that was slightly protected from wind by surrounding trees and a low ridge. The results are summarized in Table CXXXI. The average daily evaporation

TABLE CXXX.—*Average daily evaporation for weekly periods, about 25 centimeters above the ground, near the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Week ending—	Near ground in protected area.	In lawn on an exposed ridge.	Week ending—	Near ground in protected area.	In lawn on an exposed ridge.
1913.			1913.		
April 4	16.0		October 10	12.9	14.1
April 11	16.9		October 17	2.9	7.3
April 18	14.6		October 24	15.4	14.3
April 25	20.0		October 31	17.2	19.8
May 2	30.4		November 7	8.0	9.8
May 9	8.0		November 14	10.7	11.3
May 16	20.6		November 21	8.7	13.6
May 23	22.3		November 28	9.5	12.7
May 30	18.1		December 5	10.8	11.5
June 6	29.3		December 12	9.0	9.8
June 13	31.4		December 19	5.7	7.3
June 20	23.0		December 26	7.7	9.3
June 27	13.1		1914.		
July 4	15.3	16.4	January 2	11.6	12.8
July 11	9.2	13.3	January 9	10.0	12.5
July 18	6.1	6.7	January 16	12.1	16.6
July 25	8.9	9.6	January 23	13.9	18.3
August 1	6.2	10.4	January 30	13.0	17.3
August 8	6.6	9.5	February 6	14.1	17.0
August 15	15.1	16.8	February 13	13.4	18.4
August 22	11.4	11.4	February 20	15.9	23.9
August 29	9.3	9.8	February 27	16.7	25.3
September 5	11.9	15.6	March 6	16.4	23.7
September 12	12.1	15.9	March 13	21.3	29.9
September 19	12.6	16.7	March 20	22.4	33.3
September 26	12.9	13.2	March 27	22.6	36.4
October 3	14.1	15.3	April 3	23.2	39.4

TABLE CXXX.—*Average daily evaporation for weekly periods, about 25 centimeters above the ground, near the base of Mount Maquiling; altitude, 80 meters*—Continued.

Week ending—	Near ground in protected area.	In lawn on an exposed ridge.	Week ending—	Near ground in protected area.	In lawn on an exposed ridge.
1914.			1914.		
April 10	19.5	24.3	August 28	23.1	33.4
April 17	15.7	27.3	September 4	9.9	16.1
April 24	19.4	25.9	September 11	6.1	10.0
May 1	23.1	33.3	September 18	9.9	12.9
May 8	28.6	40.3	September 25	18.9	19.0
May 15	21.7	32.9	October 2	9.4	12.1
May 22	21.1	28.2	October 9	10.6	13.5
May 29	25.0	32.6	October 16	14.9	18.0
June 5	12.6	16.2	October 23	9.1	13.3
June 12	19.6	25.9	October 30	13.1	18.4
June 19	14.1	19.7	November 6	15.7	22.5
June 26	8.4	12.0	November 13	12.9	17.4
July 3	12.4	16.6	November 20	13.1	17.8
July 10	12.6	16.6	November 27	13.7	19.4
July 17	22.3	32.6	December 4	7.2	10.3
July 24	7.9	10.7	December 11	9.1	11.9
July 31	12.7	15.7	December 18	10.4	13.0
August 7	23.3	21.2	December 25	10.7	13.6
August 14	8.5	12.0	1915.		
August 21	15.1	18.0	January 1	13.3	17.5

TABLE CXXXI.—*Average daily evaporation for periods of four weeks from April, 1913, to January, 1915, in the open, about 25 centimeters above the ground, near the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Four weeks ending—	In somewhat sheltered area.	In lawn on an exposed ridge.	Four weeks ending—	In somewhat sheltered area.	In lawn on an exposed ridge.
January 30	12.3	16.2	August 14	11.2	13.3
February 27	15.0	21.2	September 11	12.4	16.3
March 27	20.7	30.8	October 9	12.7	14.6
April 24	18.2	29.2	November 6	12.1	15.5
May 22	22.0	33.7	December 4	10.8	14.3
June 19	21.7	23.6	January 1	9.7	11.9
July 17	12.4	15.8	Average	14.7	19.7

in the lawn for the entire period was 19.7 cubic centimeters, and on the bare ground in a sheltered area, 14.7 cubic centimeters. In this table, as in other previous tables, it will be noticed that the highest average rates of evaporation occur in

the dry season, from March to June; and the lowest in December, when the humidity is high and the temperature low.

As the canopy of the second-growth forest varies greatly in different places, it was thought advisable to measure the rate in several different situations. Readings were made weekly at three sites under the second-growth forest. The results are given in Table CXXXII. Evaporation was also measured in a

TABLE CXXXII.—*Average daily evaporation for weekly periods under trees near the base of Mount Maquiling; altitude, about 100 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Week ending—	Under second-growth forest.			Under culled forest on slope of ravine.
	Site 1.	Site 2.	Site 3.	
1913.				
April 4	15.1	6.6	9.6	----------
April 11	8.6	15.4	13.1	----------
April 18	5.4	7.7	6.3	----------
April 25	8.8	8,3	10.9	----------
May 2	12.5	15.6	14.6	----------
May 9	1.7	4.2	3.5	----------
May 16	8.2	8.9	9.0	----------
May 23	7.1	11.1	9.4	----------
May 30	6.0	7.1	6.7	----------
June 6	11.2	11.9	11.7	----------
June 13	14.7	16.9	13.1	----------
June 20	6.1	8.7	9.9	----------
June 27	4.2	8.1	4.8	----------
July 4	6.7	6.3	5.5	3.1
July 11	3.1	3.3	3.3	1.5
July 18	1.5	1.9	1.7	0.9
July 25	1.0	1.0	2.2	2.4
August 1	1.3	1.0	2.1	3.0
August 8	1.6	0.8	2.1	0.7
August 15	3.7	1.9	0.5	0.4
August 22	2.6	1.4	3.3	2.1
August 29	1.5	0.7	1.6	1.1
September 5	2.5	1.4	3.1	3.6
September 12	2.6	1.3	3.4	4.1
September 19	3.0	1.7	3.7	4.2
September 26	1.9	1.9	2.1	1.6
October 3	2.6	1.4	2.6	2.1
October 10	2.1	0.5	1.9	1.6
October 17	1.1	3.0	1.5	1.4
October 24	3.2	6.8	4.2	2.4
October 31	5.1	8.8	5.5	3.1
November 7	1.8	3.4	1.6	1.0
November 14	1.5	2.6	1.6	0.6
November 21	2.8	4.2	2.5	1.2
November 28	2.6	2.8	2.3	0.8
December 5	2.7	3.1	2.0	0.9
December 12	1.9	1.9	1.4	1.7

TABLE CXXXII.—*Average daily evaporation for weekly periods under trees near the base of Mount Maquiling; altitude, about 100 meters*—Cont.

Week ending—	Under second-growth forest.			Under culled forest on slope of ravine.
	Site 1.	Site 2.	Site 3.	
1913.				
December 19	1.1	1.1	0.5	0.2
December 26	2.0	2.8	1.2	0.5
1914.				
January 2	3.6	2.6	2.0	0.9
January 9	3.2	2.6	2.0	0.9
January 16	5.5	4.3	3.0	1.5
January 23	6.2	5.2	3.6	2.1
January 30	6.4	5.0	4.0	1.4
February 6	6.5	5.8	4.0	1.2
February 13	6.6	5.4	4.2	1.0
February 20	8.6	9.6	6.1	3.4
February 27	10.6	12.3	7.8	5.1
March 6	10.0	11.2	6.5	3.2
March 13	13.8	8.1	9.9	6.6
March 20	14.8	8.4	12.3	5.4
March 27	18.2	17.2	15.6	9.1
April 3	19.7	19.1	15.1	9.3
April 10	12.1	12.1	10.9	6.3
April 17	14.8	12.5	11.9	3.7
April 24	12.1	12.1	11.0	4.7
May 1	15.5	14.6	14.6	6.1
May 8	16.8	18.2	19.7	10.5
May 15	12.6	14.2	13.7	6.0
May 22	10.3	12.4	12.9	4.6
May 29	10.8	14.4	14.6	6.9
June 5	4.7	5.9	6.0	0.3
June 12	7.2	10.7	9.9	1.6
June 19	5.0	9.0	6.2	1.4
June 26	2.6	5.4	3.2	0.5
July 3	4.5	7.2	5.3	0.0
July 10	3.2	5.0	2.5	4.1
July 17	10.2	11.4	12.3	11.4
July 24	1.1	5.1	2.2	0.8
July 31	3.2	6.8	4.9	4.5
August 7	6.8	12.3	10.7	4.7
August 14	2.0	3.5	1.1	1.4
August 21	4.3	6.3	5.5	7.1
August 28	11.0	10.6	13.3	10.7
September 4	4.1	4.7	3.2	2.1
September 11	1.7	3.1	0.8	2.3
September 18	2.8	5.9	3.8	1.8
September 25	4.8	7.9	8.4	2.7
October 2	2.1	5.1	4.5	0.8
October 9	2.6	5.5	4.9	1.1
October 16	4.7	6.5	6.4	2.3
October 23	2.6	3.1	2.7	3.0
October 30	3.7	7.3	3.0	1.7
November 6	3.7	7.6	3.9	1.9

TABLE CXXXII.—*Average daily evaporation for weekly periods under trees near the base of Mount Maquiling; altitude, about 100 meters*—Cont.

Week ending—	Under second-growth forest.			Under culled forest on slope of ravine.
	Site 1.	Site 2.	Site 3.	
1914.				
November 13	3.5	6.9	2.4	1.4
November 20	4.8	7.5	2.2	2.1
November 27	5.3	8.1	5.9	4.1
December 4	0.7	4.4	3.0	1.4
December 11	2.1	6.9	3.1	0.5
December 18	3.1	7.1	3.8	0.6
December 25	4.5	10.6	2.3	1.4
1915.				
January 1	5.4	12.7	4.2	1.6

ravine under a badly culled forest at the lower edge of the dipterocarp forest at an elevation of approximately 100 meters. The results of these measurements are also given in Table CXXXII. The figures in Table CXXXII are summarized in Table CXXXIII. An examination of Table CXXXII shows that from week to week there were considerable variations in the rates at different situations under the second-growth forest; but Table CXXXIII shows that the average daily rates for the entire period are very similar, being in the different cases 6.3 cubic centimeters, 7.1 cubic centimeters, and 6 cubic centimeters. Evaporation in the ravine was considerably lower, the average daily rate for the entire period being only 3.3 cubic centimeters.

All the grass areas previously discussed, except the lawn, were covered with *Saccharum*. Weekly measurements were also made of the evaporation at the top of the grass in a large patch of *Imperata exaltata*, beginning April 11, 1913, and extending to January 1, 1915. The results are so similar to those from the large patch of *Saccharum* that they have not been presented in detail; but in Table CXXXIV the rates of evaporation in the tall-grass areas are brought together for the sake of comparison. In this table it will be seen that the average daily rate of evaporation in the large area of *Imperata* was 12.7 cubic centimeters, and in the large patch of *Saccharum*, 12.1 cubic centimeters. This table shows, as do the previous tables, that the highest rate of evaporation occurred between March and June, and the lowest, in December.

It is very striking that neither the highest average humidity nor the lowest average rate of evaporation occurred during the

TABLE CXXXIII.—*Average daily evaporation for periods of four weeks from April, 1913, to January, 1915, under trees near the base of Mount Maquiling; altitude, 100 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Four weeks ending—	Under second-growth forest.			Under culled forest on slope of ravine.
	Site 1.	Site 2.	Site 3.	
January 30	5.3	4.3	3.2	1.5
February 27	8.1	8.3	5.5	2.7
March 27	14.2	11.2	11.1	6.1
April 24	12.1	11.8	11.1	6.0
May 22	10.6	12.5	12.2	6.8
June 19	8.2	10.6	9.8	2.6
July 17	4.5	6.1	4.8	4.0
August 14	2.6	4.1	3.2	2.3
September 11	3.8	3.7	4.3	4.2
October 9	2.8	3.8	4.0	2.0
November 6	3.3	5.8	3.6	2.1
December 4	3.0	5.0	2.8	1.6
January 1	3.0	5.7	2.4	0.9
Average	6.3	7.1	6.0	3.3

TABLE CXXXIV.—*Average daily evaporation for periods of four weeks from November, 1912, to January, 1915, in tall-grass areas at the base of Mount Maquiling; altitude, about 100 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Four weeks ending—	Top of grass.			On ground under *Saccharum.*	
	Saccharum.		*Imperata.*		
	In small area.	In large area.	In large area.	In small area.	In large area.
January 31	12.6	8.2	8.8	3.8	2.6
February 28	16.2	11.9	13.3	5.6	5.0
March 28	22.4	18.7	20.6	11.0	10.8
April 25	21.9	16.3	19.4	9.9	7.9
May 23	24.8	17.3	19.7		6.1
June 20		16.1	17.9		6.6
July 18	10.1	12.0	12.4	1.4	2.4
August 15	10.7	10.3	9.6	2.0	0.3
September 12	12.0	11.0	10.3	2.8	1.5
October 10	13.3	11.1	8.5	2.7	1.8
November 7	11.7	8.9	10.2	2.3	2.3
December 5	9.3	7.8	7.9	1.0	1.8
January 2	7.9	7.3	6.9	1.2	1.3
Average	14.4	12.1	12.7	4.0	3.9

rainy months from July to September, but occurred instead during the months of November, December, and January, when temperature and light intensity were lowest. During the dry season the intense illumination, high temperature, low humidity, and great wind velocity all combine to increase evaporation; and the effect is seen very clearly in all the tables in which evaporation is recorded. During the latter part of the year the temperature is low, and the humidity is high, while the wind velocity is not usually great; also, the light is less intense than at any other time except for limited periods during the rainy season. All these factors combined produce a low rate of evaporation and appear to be more influential in this respect than are the large amounts of rain that fall between the months of June and September.

EVAPORATION IN THE DIPTEROCARP FOREST AT 300 METERS' ELEVATION

In the dipterocarp forest evaporation was measured in the top of a dominant *Parashorea;* in the crown of a second-story tree, *Dillenia philippinensis;* near the ground on a forested ridge; and in a ravine under the forest. In the last case the instrument, as previously mentioned, was placed on the bank of Molauin River at an elevation of about 300 meters and at some little distance from the other instruments. The results of the weekly readings between October, 1912, and January 1, 1915, are given in Table CXXXV and are summarized for correspond-

TABLE CXXXV.—*Average daily evaporation for weekly periods in different situations in the dipterocarp forest on Mount Maquiling; altitude, 300 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Week ending—	In top of dominant tree.	In second-story tree.	Near ground under forest.	In ravine under forest.
1912.				
October 18	7.5	----------	----------	----------
October 25	8.9	----------	1.4	----------
November 1	14.7	----------	1.7	----------
November 8	9.7	----------	1.8	1.1
November 15	7.5	----------	1.4	0.9
November 22	9.1	----------	1.1	1.0
November 29	5.1	3.1	1.2	1.1
December 6	9.1	2.6	1.0	0.9
December 13	10.0	2.6	1.0	1.0
December 20	11.4	1.9	1.1	0.8
December 27	8.7	2.0	1.1	0.7

TABLE CXXXV.—*Average daily evaporation for weekly periods in different situations in the dipterocarp forest on Mount Maquiling; altitude, 300 meters*—Continued.

Week ending—	In top of dominant tree.	In second-story tree.	Near ground under forest.	In ravine under forest.
1913.				
January 3	5.2	0.9	0.4	0.4
January 10	7.8	1.7	1.0	------
January 17	9.9	2.7	1.4	0.5
January 24	9.0	3.3	1.7	1.5
January 31	7.1	2.6	1.4	1.0
February 7	12.5	5.0	0.2	1.3
February 14	16.3	5.9	2.4	1.4
February 21	17.3	6.4	3.0	1.8
February 28	15.8	5.0	2.6	1.8
March 7	11.7	3.3	1.1	6.4
March 14	18.2	6.3	3.2	2.5
March 21	26.1	10.7	6.2	1.9
March 28	21.5	9.6	6.4	4.3
April 4	16.9	8.9	8.1	5.0
April 11	25.6	9.0	6.2	3.6
April 18	13.4	4.4	2.1	1.1
April 25	20.6	7.7	4.7	2.2
May 2	24.4	9.6	6.4	3.0
May 9	8.0	2.6	0.9	1.1
May 16	21.4	7.0	3.6	2.0
May 23	19.6	7.1	3.6	------
May 30	18.4	7.3	3.3	------
June 6	23.3	9.4	5.1	------
June 13	27.7	12.0	7.6	------
June 20	19.0	7.1	3.6	------
June 27	17.0	5.0	2.4	1.4
July 4	14.9	4.7	2.1	------
July 11	12.1	3.6	1.6	------
July 18	10.9	1.9	0.4	------
July 25	21.3	6.7	0.4	------
August 1	17.7	6.3	0.6	0.5
August 8	10.4	6.0	1.0	0.7
August 15	19.7	9.1	4.7	0.7
August 22	13.0	3.3	1.0	0.5
August 29	12.4	3.3	1.4	0.6
September 5	21.0	5.3	2.3	1.1
September 12	21.0	8.1	2.9	1.3
September 19	19.6	5.9	2.6	1.1
September 26	12.7	3.1	1.9	0.9
October 3	15.0	4.7	2.1	0.6
October 10	13.1	3.0	1.7	0.8
October 17	11.2	4.1	0.9	0.3
October 24	14.3	4.5	1.9	0.4
October 31	17.5	7.6	3.0	0.4
November 7	7.4	2.8	0.9	0.0
November 14	10.4	2.4	0.9	0.0
November 21	10.9	3.4	1.4	0.2

TABLE CXXXV.—*Average daily evaporation for weekly periods in different situations in the dipterocarp forest on Mount Maquiling; altitude, 300 meters*—Continued.

Week ending—	In top of dominant tree.	In second-story tree.	Near ground under forest.	In ravine under forest.
1913.				
November 28	11.1	3.4	1.4	0.1
December 5	10.4	2.8	1.0	0.1
December 12	8.2	1.9	0.4	0.1
December 19	5.6	1.3	0.4	0.2
December 26	7.0	1.1	0.4	0.3
1914.				
January 2	10.4	3.1	1.4	0.7
January 9	9.9	2.7	1.1	0.7
January 16	11.8	4.1	1.7	1.1
January 23	12.9	4.7	2.4	1.3
January 30	14.4	5.1	2.4	1.5
February 6	14.6	5.1	2.3	0.9
February 13	11.9	4.6	2.3	1.0
February 20	18.3	7.2	3.6	0.9
February 27	19.5	7.7	4.6	1.1
March 6	15.6	6.4	3.4	1.4
March 13	21.4	9.4	5.6	1.9
March 20	23.0	9.1	5.6	1.6
March 27	21.7	9.5	6.1	2.4
April 3	23.5	10.6	7.1	1.5
April 10	13.7	5.1	3.7	1.8
April 17	16.0	5.0	3.6	2.6
April 24	18.6	6.0	3.6	2.7
May 1	24.4	9.9	7.0	3.1
May 8	23.8	11.1	7.4	3.8
May 15	23.8	8.5	4.8	3.4
May 22	18.6	8.1	5.1	4.3
May 29	25.7	8.1	4.4	1.9
June 5	14.1	5.2	1.0	0.8
June 12	28.8	6.7	3.9	1.6
June 19	16.0	4.4	2.6	1.1
June 26	10.9	1.9	0.8	0.7
July 3	19.5	4.0	0.9	0.8
July 10	19.1	4.7	2.4	0.4
July 17	33.2	9.6	6.8	2.6
July 24	7.5	1.1	2.6	1.0
July 31	23.9	5.8	3.3	1.1
August 7	20.6	5.0	3.4	1.0
August 14	13.7	2.6	1.1	0.3
August 21	24.1	5.6	3.1	0.6
August 28	41.9	12.3	3.9	1.6
September 4	15.3	3.7	2.1	0.3
September 11	14.9	2.7	0.8	0.0
September 18	17.4	2.0	1.5	0.8
September 25	20.7	3.6	2.5	1.0
October 2	15.0	3.3	1.2	0.5

TABLE CXXXV.—*Average daily evaporation for weekly periods in different situations in the dipterocarp forest on Mount Maquiling; altitude, 300 meters*—Continued.

Week ending—	In top of dominant tree.	In second-story tree.	Near ground under forest.	In ravine under forest.
1914.				
October 9	13.6	2.1	1.1	0.4
October 16	19.5	4.1	2.1	0.8
October 23	14.9	2.0	1.0	0.3
October 30	19.9	3.9	1.9	0.5
November 6	19.8	4.9	2.0	2.6
November 13	17.8	3.3	1.4	1.8
November 20	16.6	3.1	1.6	2.6
November 27	18.7	3.8	2.0	1.5
December 4	11.1	0.6	0.0	0.2
December 11	13.0	1.5	0.9	0.4
December 18	13.5	2.2	0.9	0.9
December 25	14.0	2.4	1.6	0.9
1915.				
January 1	19.8	3.4	1.9	1.9

ing four-week periods in Table CXXXVI. The figures in this table are slightly different from those given by Brown and Matthews. This is due to the use by Brown and Matthews of figures from only one instrument, whereas the figures here given are

TABLE CXXXVI.—*Average daily evaporation for periods of four weeks from October, 1912, to January, 1915, in different situations in the dipterocarp forest on Mount Maquiling; altitude, 300 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Four weeks ending—	In top of dominant tree.	In second-story tree.	Near ground under forest.	In ravine under forest.
January 31	10.4	3.4	1.7	1.2
February 28	15.8	5.9	2.7	1.3
March 28	19.9	8.1	4.7	2.8
April 25	18.6	7.1	4.9	2.6
May 23	20.6	8.0	4.9	3.7
June 20	21.7	7.6	4.0	1.4
July 18	17.2	4.5	2.2	1.1
August 15	16.9	5.3	2.2	0.9
September 12	20.5	5.6	2.2	0.8
October 10	15.9	3.5	1.9	0.8
November 7	13.8	4.3	1.7	0.7
December 5	11.5	2.9	1.2	0.9
January 2	10.6	2.1	1.0	0.7
Average	16.4	5.3	2.7	1.5

averages from several. The figures in Table CXXXVI are plotted in fig. 21. From Table CXXXVI it will be seen that the average daily evaporation in the top of the dominant tree was 16.4 cubic centimeters, which is somewhat lower than in the top of the second-growth tree at an elevation of 80 meters, where the average was 21.6 cubic centimeters. The daily rate of evaporation in the crown of the second-story tree was very considerably lower, being 5.3 cubic centimeters, or 32 per cent of that in the top of the dominant tree. On the ground under the forest it was lower still, being 2.7 cubic centimeters, or 16 per cent of the amount in the top of the dominant tree. The evaporation in the ravine was even lower than near the ground on a ridge, being only 1.5 cubic centimeters, or 9 per cent of that in the top of the dominant tree. It will thus be seen that the rate of evaporation varies greatly in different situations within the dipterocarp forest, being about eleven times as great in the top of the dominant tree as in the ravine. The differences in the rates of evaporation in the different situations are shown very clearly in fig. 21. The curves for the dipterocarp forest show the same general character as do those for the parang, the lowest rate, except in the case of the dominant tree, occurring during the four weeks ending January 2. In the dominant tree the rate for this period was slightly higher than for that ending January 31.

The maximum daily evaporation for any one-week period in the top of the dominant tree was 41.9 cubic centimeters, and the minimum, 5.1. In the second-story tree the maximum was 12.3 cubic centimeters, and the minimum, 0.6. Near the ground on the ridge the maximum was 8.1 cubic centimeters, and in the ravine, 6.4. The minimum in the last two cases was 0.0.

It is interesting to note that the greatest amount of epiphytic vegetation occurs in the tops of the trees, where the rate of evaporation is high. These epiphytes being on the larger branches are of course not exposed to so high a rate of evaporation as is the uppermost portion of the dominant canopy, but they are exposed to rates that are higher than those at lower levels in the forest. These epiphytes are for the most part provided with water-storage tissue, and all have leathery, xerophytic leaves. They are thus constituted to stand the high rates of evaporation, while they are exposed advantageously for the reception of light and rain. The absence of phanerogamic epiphytes at lower levels in the forest is probably connected to a large extent with the decreased light intensity in these situations.

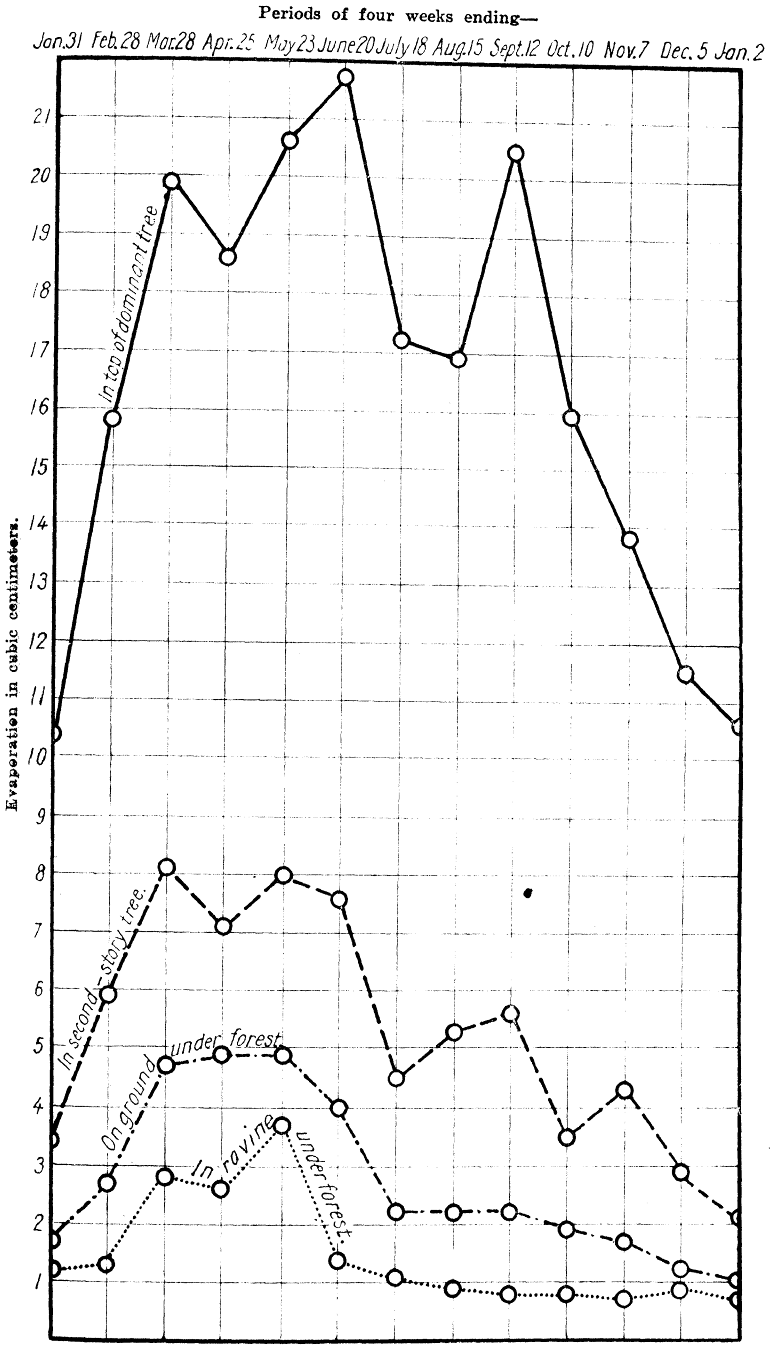

FIG. 21. Average daily rate of evaporation in different situations in the dipterocarp forest, Mount Maquiling; altitude, 300 meters.

Though the evaporation rates appear to be fairly low under the forest, they do not seem, as will be shown later, to be low enough for the development there of a thick covering of mosslike plants. The atmosphere in this forest is probably rarely saturated with moisture, and the absence of clouds from which water would be condensed on mosslike plants is probably as important as evaporation in preventing the development of a thick covering of such plants. Epiphytes on the trunks of the trees are very scarce in this forest.

TABLE CXXXVII.—*Average daily evaporation for weekly periods in different situations in the dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Week ending—	In top of dominant tree.	In second-story tree.	Near ground under forest.		Near ground in open.
			Top of ridge.	Side of ridge.	
1913.					
August 15	16.0	12.8	4.8	1.9	8.9
August 22	12.5	3.3	1.7	1.4	5.6
August 29	11.3	5.2	1.7	1.5	5.7
September 5	10.0	5.4	1.8	1.2	5.2
September 12	20.7	13.1	4.6	3.3	6.5
September 19	13.2	9.4	3.9	3.0	6.3
September 26	10.9	5.1	2.7	1.8	7.3
October 3	13.6	6.7	4.3	2.3	10.3
October 10	11.9	5.0	2.9	1.7	9.3
October 17	9.4	5.6	0.8	1.4	3.0
October 24	12.4	5.7	3.2	2.4	9.5
October 31	14.6	8.7	5.8	1.8	10.9
November 7	5.3	1.9	1.4	0.9	3.6
November 14	8.0	3.3	2.8	1.4	4.9
November 21	9.5	5.3	2.7	1.9	6.4
November 28	10.2	4.5	3.4	1.8	5.9
December 5	9.6	5.1	3.5	1.7	3.7
December 12	6.4	2.7	1.5	0.6	1.9
December 19	3.5	1.0	0.8	0.4	1.1
December 26	6.1	1.3	0.7	0.5	1.7
1914.					
January 2	7.3	2.9	1.6	0.8	2.1
January 9	8.5	3.4	1.7	1.3	2.8
January 16	10.2	3.9	3.4	2.2	3.8
January 23	12.3	5.3	2.6	2.5	4.9
January 30	13.7	6.0	3.0	2.7	6.3
February 6	14.2	6.5	4.7	2.6	7.0
February 13	13.1	5.4	3.0	2.1	4.0
February 20	18.3	10.1	5.0	3.4	9.4
February 27	20.3	11.8	4.6	1.3	12.0
March 6	13.5	6.1	4.1	2.8	7.1
March 13	21.9	10.4	6.7	5.8	13.0

TABLE CXXXVII.—*Average daily evaporation for weekly periods in different situations in the dipterocarp forest on Mount Maquiling; altitude, 450 meters.*—Continued.

Week ending—	In top of dominant tree.	In second-story tree.	Near ground under forest.		Near ground in open.
			Top of ridge.	Side of ridge.	
1914.					
March 20	20.9	12.1	8.0	5.6	12.1
March 27	20.1	11.9	5.3	6.9	12.6
April 3	21.9	11.3	10.0	7.8	14.6
April 10	11.2	4.4	4.0	3.3	7.1
April 17	19.1	5.8	4.0	4.5	9.4
April 24	17.3	6.0	3.8	3.9	7.5
May 1	25.2	10.9	5.4	7.8	13.8
May 8	20.0	10.8	7.3	3.6	13.4
May 15	19.0	9.8	5.7	5.3	12.4
May 22	20.4	9.5	5.0	6.6	11.4
May 29	22.1	10.1	5.9	6.8	14.2
June 5	14.9	7.1	2.4	4.4	6.8
June 12	19.9	8.5	3.9	5.7	8.6
June 19	13.8	6.1	2.9	3.7	5.7
June 26	10.5	3.2	1.2	1.6	3.5
July 3	17.9	8.3	2.5	3.8	3.9
July 10	16.0	7.8	2.1	1.1	2.5
July 17	19.7	10.6	3.6	5.3	5.6
July 24	11.4	2.9	0.3	1.1	5.8
July 31	17.5	9.1	3.5	5.0	5.5
August 7	20.1	8.1	3.2	5.3	11.0
August 14	9.2	4.5	0.7	1.3	1.4
August 21	20.2	9.4	2.9	4.0	7.0
August 28	23.5	12.6	5.8	7.6	10.6
September 4	6.8	3.2	0.9	1.1	2.7
September 11	6.0	2.2	0.4	0.7	0.9
September 18	15.7	6.5	2.4	2.9	3.4
September 25	19.5	7.8	3.2	2.6	3.9
October 2	15.8	7.6	2.2	2.8	4.8
October 9	10.4	4.0	1.5	2.1	3.3
October 16	14.8	6.8	3.2	4.4	6.3
October 23	10.1	4.0	1.3	1.7	4.6
October 30	13.6	5.6	2.4	2.6	6.9
November 6	14.0	5.9	2.4	3.1	7.3
November 13	12.2	4.8	1.8	2.6	5.4
November 20	12.5	5.3	2.1	3.1	6.4
November 27	14.0	6.1	2.3	2.9	7.9
December 4	4.5	9.9	0.3	0.7	11.4
December 11	6.3	1.8	0.5	0.3	3.4
December 18	10.0	2.8	1.0	1.3	4.9
December 25	9.7	3.3	0.8	1.2	4.0
1915.					
January 1	14.8	6.2	2.4	2.9	7.4

EVAPORATION IN THE DIPTEROCARP FOREST AT 450 METERS' ELEVATION

The rates of evaporation at an altitude of 450 meters were recorded in the top of a dominant tree; in the crown of a second-story tree; under the forest on the top and at the side of a ridge; also near the ground in the center of a clearing made by removing the trees from the plot used for detailed measurements of vegetation at this elevation. Readings were begun in August, 1913, and continued until January, 1915. The weekly results are presented in Table CXXXVII and are summarized in Table CXXXVIII for corresponding four-week periods. The rates of evaporation for four-week periods in different situations are shown graphically in fig. 22. In the top of the dominant tree the daily rates are somewhat lower than

TABLE CXXXVIII.—*Average daily evaporation for periods of four weeks from August, 1913, to January, 1915, in different situations in the dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Four weeks ending—	In top of dominant tree.	In second-story tree.	Near ground under forest.		Near ground in open.
			Top of ridge.	Side of ridge.	
January 30	11.2	4.7	2 7	2.2	4.5
February 27	16.5	8.5	4.3	2.4	8.1
March 27	19.1	10.1	6.0	5.3	11.2
April 24	17.4	6.9	5.5	4.9	9.7
May 22	21.2	10.3	5.9	5.8	12.8
June 19	17.7	8.0	3.8	5.2	8.8
July 17	16.0	7.5	2.4	3.0	3.9
August 14	14.6	6.2	1.9	3.2	5.9
September 11	13.9	6.9	2.5	2.7	5.6
October 9	13.9	6.6	2.9	2.4	6.1
November 6	11.8	5.6	2.6	2.3	6.6
December 4	10.1	5.6	2.4	2.0	6.5
January 1	8.0	2.8	1.2	1.0	3.3
Average	14.7	6.9	3.4	3.3	7.2

at 300 meters' elevation, averaging 14.7 cubic centimeters at 450 meters and 16.4 at 300. The instrument in the second-story tree was near the top of the crown and in a rather exposed position. It showed a daily rate of evaporation of 6.9 cubic centimeters, which is 1.6 cubic centimeters more than the rate in the second-story tree at 300 meters' elevation. This difference is due to the position of the instruments in the two cases, as at 300

meters the atmometer was placed in the center of the crown under a dense canopy. An examination of Table CXXXVII shows that the rate near the ground on the top and at the side of the ridge varied considerably from week to week. The same difference is also evident in the four-week periods given in Table CXXXVIII. The average daily rates for the entire period are very similar, however, being 3.4 cubic centimeters in one case and 3.3 in the other. Both of these averages are higher than the average rate near the ground at 300 meters' elevation. The difference is probably due to exposure, as the station at 450 meters' elevation was on a sloping ridge, while that at 300 meters' elevation was on more even ground. Moreover, the ridge at 450 meters was more exposed than that at 300 meters. At 450 meters the evaporation near the ground was 23 per cent of that in the top of the tree. The evaporation near the ground in the open was less than half that in the top of the dominant tree. This at first might seem strange, particularly in view of the fact that at 80 meters' elevation the rate of evaporation in the lawn was only very slightly less than that in the top of the second-growth tree. However, although the clearing at 450 meters was on a ridge, in an open situation, so that the surrounding country could be seen from the place where the atmometer was located, it is still probable that the instrument was not so much exposed to the action of the wind as was that in the top of the tree. The differences in the rates of evaporation in the different situations are brought out very clearly in fig. 22. From the curves in this figure it will be seen that the lowest rate of evaporation occurred in every case during the period ending January 1. The similarity in the rates of evaporation under the forest on the top and at the side of the ridge is shown clearly. Moreover, these curves show that the rates near the ground in the open and in the top of the second-story tree were not very different, while the rate was much higher in the top of the dominant tree than in any other situation.

The maximum daily evaporation in the top of the dominant tree for a one-week period was 25.2 cubic centimeters, and the minimum, 3.5 cubic centimeters. Near the ground on the ridge the maximum was 10.0 cubic centimeters, and the minimum, 0.3. Near the ground on the side of the ridge the maximum was 7.8 cubic centimeters, and the minimum, 0.3. Near the ground in the open the maximum was 14.6 cubic centimeters, and the minimum, 0.9.

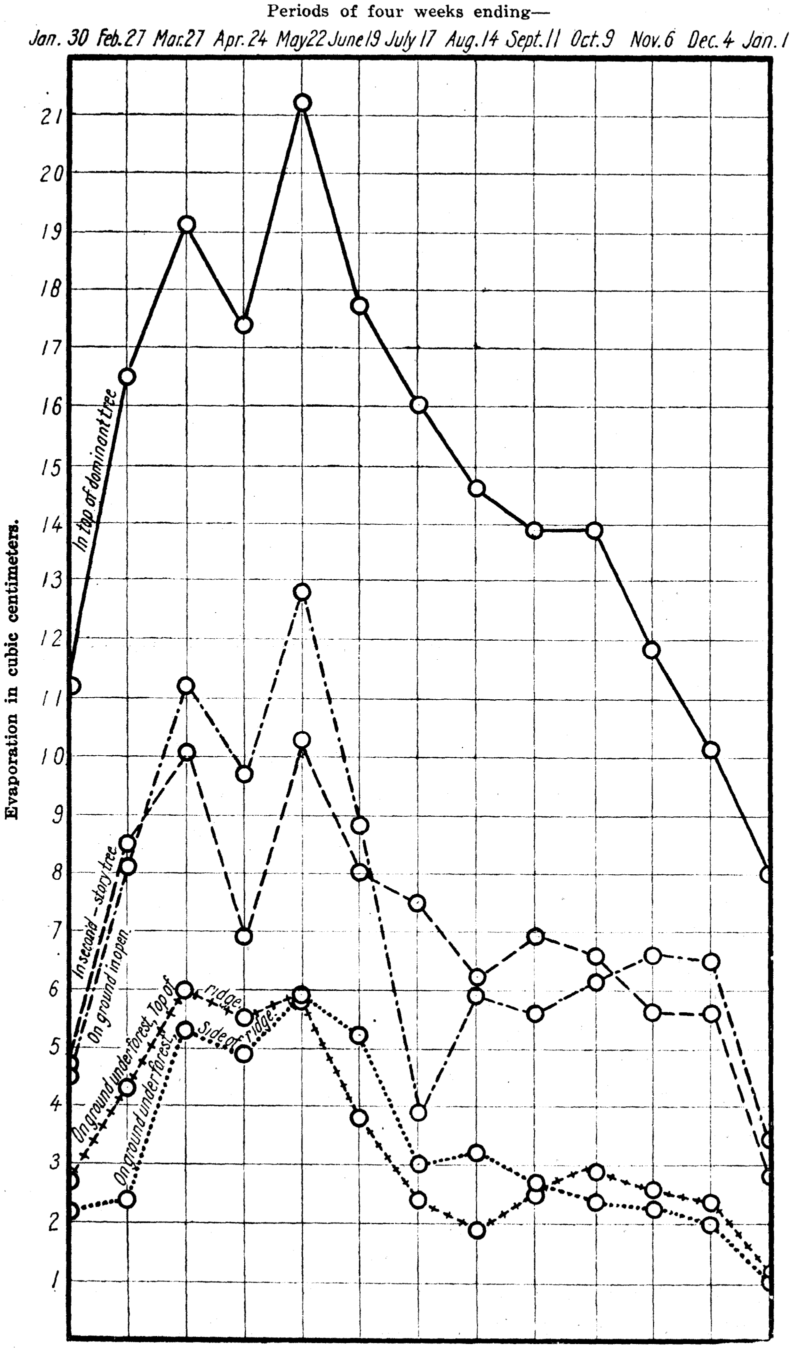

FIG. 22. Average daily rate of evaporation in different situations in the dipterocarp forest, Mount Maquiling; altitude, 450 meters.

EVAPORATION IN THE MIDMOUNTAIN FOREST AT 740 METERS' ELEVATION

The rates of evaporation at this elevation were recorded in the top of a dominant tree, in the crown of a second-story tree, near the ground under the forest, and under the forest in a ravine at the side of a ridge. The weekly readings from November, 1912, to January 1, 1915, are given in Table CXXXIX

TABLE CXXXIX.—*Average daily evaporation for weekly periods in different situations in the midmountain forest on Mount Maquiling; altitude, 740 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Week ending—	In top of dominant tree.	In second-story tree.	Near ground under forest.	In ravine under forest.
1912.				
November 8	3.2	----------	----------	0.2
November 15	3.9	----------	0.3	0.2
November 22	4.0	----------	0.3	0.2
November 29	2.9	----------	0.2	0.0
December 6	6.8	4.4	0.9	4.1
December 13	2.9	0.7	0.5	0.2
December 20	5.3	1.0	1.4	0.3
December 27	3.4	0.5	0.4	0.2
1913.				
January 3	1.0	0.3	0.1	0.03
January 10	2.5	0.5	0.2	0.3
January 17	4.0	1.1	0.6	0.3
January 24	6.9	1.0	0.9	0.0
January 31	2.0	1.0	0.7	0.0
February 7	3.9	1.1	0.5	0.5
February 14	6.2	0.7	0.7	0.0
February 21	7.6	2.7	1.4	0.3
February 28	6.3	3.3	1.8	0.3
March 7	3.2	1.5	0.4	0.0
March 14	9.9	3.0	1.9	0.6
March 21	16.7	6.2	4.3	0.2
March 28	13.7	6.0	4.5	1.9
April 4	10.8	7.8	3.6	1.6
April 11	12.0	----------	4.7	2.1
April 18	3.6	----------	1.2	0.6
April 25	8.5	----------	2.0	1.1
May 2	11.3	----------	2.5	1.5
May 9	1.9	----------	0.0	0.0
May 16	14.5	----------	4.4	2.0
May 23	11.0	----------	2.8	3.1
May 30	9.9	----------	2.5	2.1
June 6	13.6	----------	4.2	1.7
June 13	16.6	----------	6.2	2.7
June 20	11.4	----------	3.6	1.1
June 27	11.3	----------	5.2	1.2
July 4	8.3	4.6	1.3	0.6

TABLE CXXXIX.—*Average daily evaporation for weekly periods in different situations in the midmountain forest on Mount Maquiling; altitude, 740 meters*—Continued.

Week ending—	In top of dominant tree.	In second-story tree.	Near ground under forest.	In ravine under forest.
1913.				
July 11	6.8	4.3	3.5	1.2
July 18	2.9	2.2	1.2	0.6
July 25	1.7	0.8	0.3	0.0
August 1	2.0	1.6	1.5	0.2
August 8	5.2	3.8	2.6	0.2
August 15	8.3	6.2	4.6	0.6
August 22	7.2	5.2	2.9	0.3
August 29	5.3	4.2	2.0	0.5
September 5	5.3	5.4	3.0	0.3
September 12	7.4	6.4	3.5	0.5
September 19	7.7	6.6	4.0	0.6
September 26	5.6	3.7	1.4	0.4
October 3	8.0	6.2	2.1	0.5
October 10	7.1	4.7	1.8	0.5
October 17	4.6	4.1	3.2	0.5
October 24	6.0	3.7	1.3	0.4
October 31	6.8	4.9	1.6	0.4
November 7	1.5	0.6	0.2	0.1
November 14	3.7	2.3	0.4	0.1
November 21	3.2	1.5	0.4	0.04
November 28	4.5	2.8	0.7	0.1
December 5	4.2	2.1	0.4	0.1
December 12	2.0	0.8	0.0	0.0
December 19	0.7	0.1	0.0	0.0
December 26	3.5	2.8	0.7	0.3
1914.				
January 2	1.1	0.5	0.3	0.2
January 9	4.9	2.7	0.5	0.3
January 16	5.7	2.6	0.6	0.3
January 23	5.0	3.4	0.6	0.3
January 30	7.5	5.4	0.9	0.4
February 6	6.7	5.4	1.2	0.3
February 13	4.0	3.1	0.8	0.1
February 20	10.7	9.9	3.0	1.4
February 27	11.1	8.7	3.9	1.7
March 6	3.5	5.0	1.1	1.6
March 13	12.7	11.6	4.0	0.9
March 20	10.7	7.8	2.6	0.9
March 27	9.8	7.3	3.0	1.4
April 3	11.5	9.1	4.2	1.1
April 10	5.3	2.9	0.9	0.4
April 17	9.6	7.9	2.7	0.7
April 24	8.6	6.0	2.0	0.4
May 1	14.3	11.0	4.3	0.7
May 8	10.7	7.4	3.5	1.7
May 15	11.0	8.1	3.0	1.7
May 22	9.9	9.1	4.1	2.4

TABLE CXXXIX.—*Average daily evaporation for weekly periods in different situations in the midmountain forest on Mount Maquiling; altitude, 740 meters*—Continued.

Week ending—	In top of dominant tree.	In second-story tree.	Near ground under forest.	In ravine under forest.
1914.				
May 29	13.8	10.2	4.6	1.4
June 5	6.7	5.4	1.9	1.3
June 12	11.6	8.6	3.4	1.9
June 19	6.6	2.4	1.6	0.5
June 26	7.3	4.1	1.6	0.5
July 3	9.1	7.4	4.1	1.7
July 10	4.5	3.4	1.6	0.4
July 17	6.8	5.3	1.9	0.7
July 24	5.3	3.2	1.0	0.3
July 31	10.5	9.4	4.1	1.4
August 7	15.9	7.2	2.9	0.9
August 14	3.6	2.6	0.8	0.3
August 21	9.6	9.1	3.8	0.9
August 28	7.1	5.8	1.8	0.6
September 4	0.3	0.5	0.0	0.0
September 11	1.0	0.4	0.3	0.0
September 18	13.7	10.1	5.6	0.7
September 25	12.0	9.5	4.6	0.5
October 2	10.1	7.9	2.1	0.6
October 9	9.6	3.1	0.9	0.2
October 16	6.8	4.1	1.4	0.4
October 23	5.2	2.6	0.3	0.04
October 30	5.4	3.2	0.5	0.3
November 6	6.6	3.8	0.4	0.1
November 13	5.3	3.2	0.4	0.5
November 20	5.8	3.8	0.2	0.0
November 27	5.9	4.5	0.6	0.0
December 4	1.2	0.5	0.0	0.0
December 11	2.4	0.9	0.0	0.0
December 18	3.6	3.8	0.3	0.1
December 25	4.8	3.3	0.6	0.3
1915.				
January 1	5.7	5.5	0.5	0.3

and are summarized for corresponding four-week periods in Table CXL. The rates were very much lower at this elevation than in the dipterocarp forest. The average daily rate in the top of the dominant tree was 7.2 cubic centimeters, which is 49 per cent of that in the top of the tree at an elevation of 450 meters, and 44 per cent of that at 300 meters' elevation. In this forest the atmometer in the second-story tree was placed in the lower part of the crown of a *Dillenia reifferscheidia.* In spite of the fact that the atmometer in the second-story

TABLE CXL.—*Average daily evaporation for periods of four weeks from November, 1912, to January, 1915, in different situations in the midmountain forest on Mount Maquiling; altitude, 740 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Four weeks ending—	In top of dominant tree.	In second-story tree.	Near ground under forest.	In ravine under forest.
January 31	4.9	2.2	0.7	0.3
February 28	7.1	4.4	1.7	0.6
March 28	10.1	6.1	2.8	1.0
April 25	8.8	7.2	2.7	1.1
May 23	10.6	8.9	3.1	1.7
June 20	11.3	6.7	3.5	1.6
July 18	7.1	4.7	2.6	0.8
August 15	6.6	4.4	2.3	0.5
September 12	5.4	4.7	2.2	0.4
October 10	9.3	6.5	2.8	0.5
November 7	5.4	3.4	1.2	0.3
December 5	4.3	2.6	0.4	0.4
January 2	3.0	1.7	0.4	0.2
Average	7.2	4.9	2.0	0.7

tree was in the lower portion of the crown, there was nothing like so great a difference here between the rate in the second-story tree and that in the top of the dominant tree as there was at lower elevations. This would seem to be very evidently connected with the more open character of the canopy in the midmountain forest. The average daily rate for the entire period in the second-story tree was 4.9 cubic centimeters, which is 68 per cent of that in the top of the dominant tree. The average daily rate near the ground under the forest was 2 cubic centimeters, or 28 per cent of that in the top of the dominant tree. At an elevation of 300 meters the rate on the ground was 16 per cent of that in the top of the dominant tree, and at 450 meters it was 23 per cent. The rate in the ravine was much less than that near the ground on the top of the ridge. In the ravine the average daily rate was 0.7 cubic centimeter, which is 35 per cent of that on the ridge and 10 per cent of that in the top of the dominant tree. The rates of evaporation under the forest are considerably less than those in similar situations at lower elevations. This probably accounts in large part for the greater development of epiphytes, particularly cryptogamic ones, on the trunks of the trees in the midmountain forest than in the dipterocarp forest. Fogs, which are of more frequent occurrence here than at lower altitudes, may be a contributing factor.

The rates of evaporation for four-week periods in the different situations are plotted in fig. 23. A comparison of this curve with the curves for lower elevations emphasizes the fact that the difference between the rates of evaporation in the top of a dominant tree and those in the second-story tree is not so great as at lower altitudes. These curves, like those for lower altitudes, show very strikingly the high rates of evaporation during the dry season. In this case the high rates were particularly marked in April and May. A second or lower maximum is shown even more strikingly than at lower elevations. In the midmountain forest the second maximum is very definite for the period ending October 10. All the curves show a lower rate during the rainy season than either immediately before or immediately after it. In every case the lowest average minimum for a four-week period occurs during the period ending January 2.

The maximum daily evaporation for a one-week period in the top of the dominant tree was 16.7 cubic centimeters, and the minimum, 0.3.

In the second-story tree the maximum was 11.6 cubic centimeters, and the minimum, 0.1. Near the ground under the forest the maximum was 6.2 cubic centimeters, and in the ravine, 4.1. In both of the last situations the minimum was 0.0.

EVAPORATION IN THE MOSSY FOREST

In the mossy forest evaporation was measured at the summit of the east peak on Mount Maquiling for the period from October, 1912, to January, 1915. Atmometers were placed in the top of a dominant tree, in the crown of a dominant tree, near the ground under the forest, in a shallow ravine near the summit of the peak, and also on a pole the top of which was at about the level of the forest. The weekly readings of these atmometers are given in Table CXLI and are summarized for corresponding four-week periods for the entire time in Table CXLII.

The maximum daily rates for a one-week period were: in the top of the dominant tree, 21.6 cubic centimeters; on the pole, 14.4; near the ground under the forest, 2.5; in the ravine, 1.9; and in the crown of a dominant tree, 4.7. In all cases the minimum was 0.0.

An examination of Table CXLII shows that, while the rates in the top of the tree and on the pole varied from time to time, the average rate for the entire period was very similar

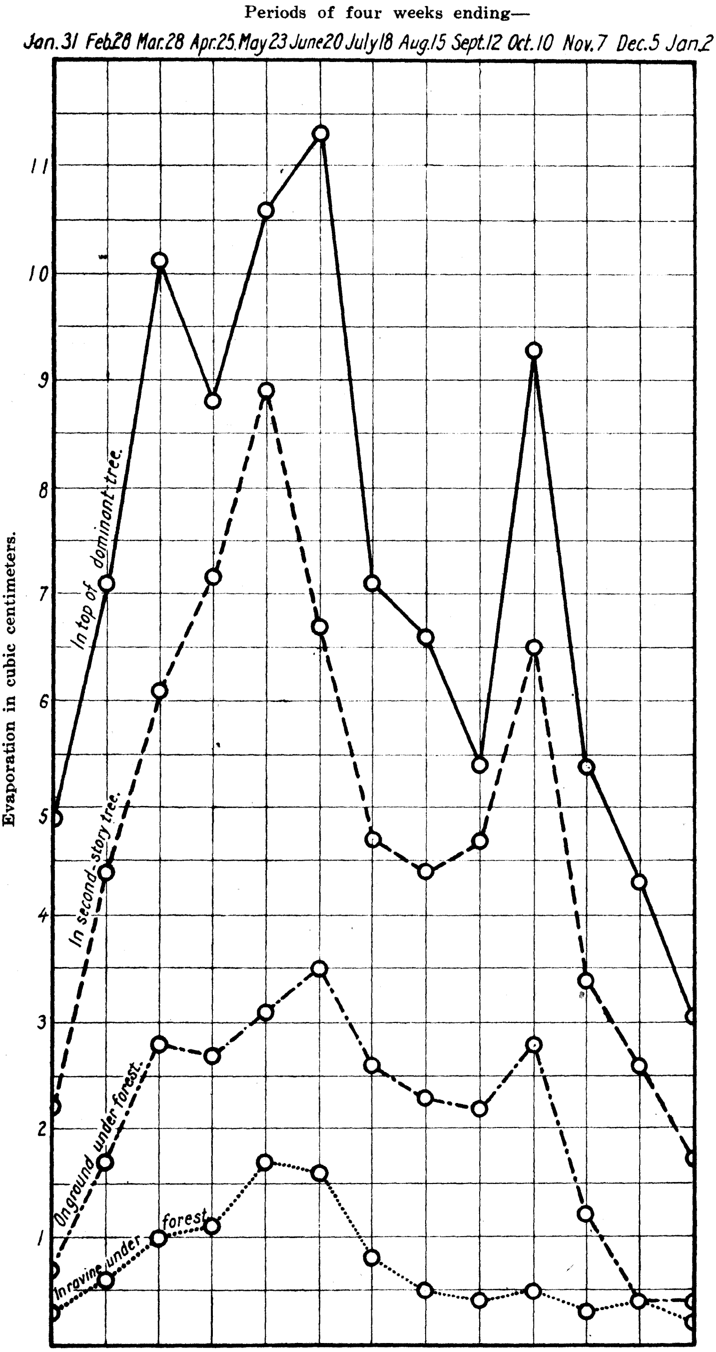

FIG. 23. Average daily rate of evaporation in different situations in the midmountain forest, Mount Maquiling; altitude, 740 meters.

TABLE CXLI.—*Average daily evaporation for weekly periods in different situations in the mossy forest at the top of Mount Maquiling; altitude, 1,050 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Week ending—	In top of dominant tree.	On pole.	In crown of dominant tree.	Near ground under forest.	In ravine under forest.
1912.					
October 18	----------	2.1	----------	0.3	----------
October 25	----------	2.5	----------	0.1	----------
November 1	----------	----------	----------	0.1	----------
November 8	----------	----------	----------	0.2	----------
November 15	----------	2.4	----------	0.0	----------
November 22	----------	4.6	----------	0.0	----------
November 29	----------	1.9	0.0	0.0	----------
December 6	----------	4.4	0.4	0.3	----------
December 13	0.4	3.1	0.0	0.0	0.2
December 20	2.1	----------	0.4	0.0	0.0
December 27	1.7	2.1	0.1	0.1	0.03
1913.					
January 3	0.2	0.3	0.01	0.1	0.0
January 10	2.2	2.9	0.0	0.0	0.0
January 17	3.5	3.9	0.5	0.0	0.0
January 24	3.8	4.1	0.3	0.3	0.0
January 31	1.0	1.2	0.0	0.0	0.0
February 7	2.2	2.7	0.0	0.0	0.0
February 14	3.6	3.9	0.6	0.3	0.3
February 21	3.6	3.4	0.0	0.0	0.0
February 28	4.0	3.1	0.0	0.0	0.0
March 7	1.4	2.4	0.2	0.2	0.0
March 14	7.5	9.3	0.8	0.4	0.3
March 21	10.5	11.5	1.1	0.5	0.4
March 28	10.6	12.2	1.0	0.7	0.4
April 4	9.5	10.5	1.0	0.5	0.2
April 11	13.7	13.3	2.3	2.5	0.9
April 18	2.6	3.1	0.5	0.5	0.2
April 25	6.6	5.1	0.5	0.4	0.2
May 2	6.7	10.8	0.3	0.04	0.0
May 9	0.6	0.9	0.0	0.0	0.0
May 16	11.4	14.4	2.2	1.3	1.5
May 23	9.3	9.2	0.9	0.5	0.3
May 30	6.9	8.0	0.6	0.4	0.4
June 6	9.4	10.1	1.0	0.8	0.4
June 13	12.2	13.1	2.2	1.7	1.5
June 20	9.9	10.6	1.4	0.8	0.7
June 27	7.2	8.2	1.4	1.0	1.0
July 4	8.7	9.4	4.7	0.2	0.6
July 11	3.4	4.8	0.3	0.2	0.5
July 18	2.3	2.7	0.0	0.0	0.0
July 25	0.4	0.4	0.2	0.0	0.0
August 1	0.9	0.9	0.0	0.0	0.1
August 8	0.8	0.7	0.0	0.0	0.0
August 15	1.5	1.6	0.04	0.0	0.0
August 22	3.2	6.8	0.1	0.0	0.0
August 29	3.2	3.2	0.0	0.0	0.0

TABLE CXLI.—*Average daily evaporation for weekly periods in different situations in the mossy forest at the top of Mount Maquiling; altitude, 1,050 meters*—Continued.

Week ending—	In top of dominant tree.	On pole.	In crown of dominant tree.	Near ground under forest.	In ravine under forest.
1913.					
September 5	3.2	4.1	0.5	0.04	0.3
September 12	3.8	4.6	0.2	0.04	0.1
September 19	5.2	4.9	0.3	0.1	0.2
September 26	5.6	6.4	0.0	0.0	0.0
October 3	7.6	7.4	0.0	0.0	0.2
October 10	6.8	7.4	0.6	0.4	0.2
October 17	2.4	2.3	0.4	0.0	0.0
October 24	4.8	6.3	0.4	0.0	0.0
October 31	5.0	6.8	0.0	0.0	0.0
November 7	0.9	2.1	0.0	0.0	0.0
November 14	3.0	4.0	0.0	0.0	0.0
November 21	3.4	2.1	0.0	0.0	0.4
November 28	2.1	2.4	0.0	0.0	0.1
December 5	2.7	4.1	0.04	0.0	0.1
December 12	0.7	1.4	0.1	0.1	0.1
December 19	0.2	0.7	0.0	0.0	0.0
December 26	2.0	3.0	0.0	0.0	0.0
1914.					
January 2	0.4	0.6	0.1	0.0	0.0
January 9	3.2	2.8	0.2	0.2	0.1
January 16	2.6	3.3	0.1	0.04	0.0
January 23	3.4	4.4	0.0	0.0	0.0
January 30	5.1	4.1	0.0	0.2	0.04
February 6	5.1	5.2	0.0	0.0	0.0
February 13	2.8	2.6	0.4	0.0	0.1
February 20	10.3	7.0	0.9	0.6	0.3
February 27	10.8	6.7	3.0	0.2	0.9
March 6	3.3	4.2	0.0	0.04	0.0
March 13	13.2	9.3	4.6	2.5	0.2
March 20	9.4	8.1	1.4	0.6	1.9
March 27	7.4	7.5	1.5	0.5	0.7
April 3	9.2	9.3	0.9	0.7	0.9
April 10	3.4	4.1	0.0	0.0	0.0
April 17	8.0	6.6	1.7	2.5	0.8
April 24	7.0	6.5	0.6	0.4	0.6
May 1	12.5	8.9	2.4	2.0	0.8
May 8	21.6	7.1	0.8	0.7	0.6
May 15	9.2	6.6	0.3	0.7	0.6
May 22	8.8	7.4	1.2	1.1	0.6
May 29	13.1	9.2	0.9	1.1	0.7
June 5	4.7	4.1	0.	0.4	0.0
June 12	11.2	8.6	1.3	0.1	1.2
June 19	5.1	4.9		0.0	0.0
June 26	6.6	7.2	0.4	0.4	0.3
July 3	4.4	3.0	0.0	0.0	0.0
July 10	0.9	0.7	0.0	0.0	0.0
July 17	1.5	2.1	0.0	0.0	0.0

TABLE CXLI.—*Average daily evaporation for weekly periods in different situations in the mossy forest at the top of Mount Maquiling; altitude, 1,050 meters*—Continued.

Week ending—	In top of dominant tree.	On pole.	In crown of dominant tree.	Near ground under forest.	In ravine under forest.
1914.					
July 24	3.4	3.8	0.0	0.0	0.0
July 31	7.3	7.7	1.9	0.9	0.2
August 7	9.0	6.5	1.2	0.0	0.4
August 14	1.5	1.4	0.0	0.0	0.0
August 21	4.6	4.3	0.0	0.0	0.0
August 28	1.9	1.7	0.0	0.0	0.0
September 4	0.0	0.0	0.0	0.0	0.0
September 11	0.6	0.0	0.0	0.0	0.0
September 18	8.1	8.9	2.1	2.1	0.4
September 25	9.5	9.1	1.5	0.8	0.3
October 2	7.6	7.6	1.3	0.8	0.2
October 9	4.3	5.5	0.2	0.1	0.1
October 16	3.6	6.1	0.0	0.0	0.0
October 23	3.5	5.4	0.1	0.0	0.0
October 30	2.7	4.4	0.1	0.1	0.2
November 6	4.4	6.3	0.0	0.04	0.0
November 13	4.0	5.6	0.0	0.0	0.0
November 20	4.8	9.0	0.3	0.04	0.2
November 27	3.6	6.0	0.0	0.0	0.0
December 4	0.6	2.4	0.0	0.0	0.0
December 11	1.2	3.0	0.0	0.0	0.0
December 18	3.9	5.7	0.0	0.0	0.0
December 25	2.9	4.0	0.04	0.3	0.0
1915.					
January 1	4.4	6.9	0.2	0.3	0.2

in the two cases. In the top of the dominant tree the average daily rate was 5.3 cubic centimeters, and on the pole, 5.4. These two situations may very well be taken to represent readings in two different places in the main canopy.

The average daily evaporation in the top of the dominant tree, 5.3 cubic centimeters, was 1.9 less than in the midmountain forest. The rate in the crown of the dominant tree was very much lower than in the top of the tree and approached the rate on the ground. The average daily rate in the crown of the dominant tree was 0.6 cubic centimeter, which is only 11 per cent of that in the top of the dominant tree. This difference is greater than that between the rate of evaporation in the top of the dominant tree and the rate in the second-story tree at any of the lower elevations.

The average daily evaporation near the ground was 0.4 cu-

TABLE CXLII.—*Average daily evaporation for periods of four weeks from November, 1912, to January, 1915, in different situations in the mossy forest at the top of Mount Maquiling; altitude, 1,050 meters.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Four weeks ending—	In top of dominant tree.	On pole.	In crown of dominant tree.	Near ground under forest.	In ravine under forest.
January 31	3.1	3.4	0.2	0.1	0.02
February 28	5.4	4.4	0.7	0.2	0.2
March 28	7.9	8.1	1.4	0.7	0.5
April 25	7.5	7.3	1.0	1.0	0.5
May 23	10.0	8.2	1.1	0.8	0.6
June 20	9.1	8.6	1.0	0.7	0.7
July 18	4.4	4.8	0.9	0.3	0.3
August 15	3.1	2.9	0.5	0.1	0.1
September 12	2.6	3.1	0.1	0.01	0.05
October 10	6.9	7.2	0.8	0.6	0.3
November 7	3.5	5.0	0.2	0.1	0.05
December 5	3.1	4.1	0.1	0.04	0.2
January 2	1.7	2.7	0.1	0.1	0.1
Average	5.3	5.4	0.6	0.4	0.3

bic centimeter, which is only 8 per cent of that in the top of the dominant tree. This difference between the rate near the ground and that in the top of the dominant tree is very much greater than at lower elevations. In the ravine the average daily evaporation was still lower, being only 0.3 cubic centimeter, or 6 per cent of what it was in the top of the dominant tree. The low rates of evaporation in the crown of the tree and near the ground, as compared with those in the top of the dominant tree, would seem to be sufficient to explain the presence of the dense covering of filmy ferns, liverworts, and delicate mosses on the trunks of the trees and their much less abundance on exposed branches and leaves. An examination of Table CXLI shows that there were many weeks during which no evaporation was recorded in the crown of the dominant tree, near the ground, or in the ravine. Beginning with October 17, 1913, there were eight consecutive weeks when there was no evaporation near the ground under the forest, while in a number of other cases there was no evaporation for considerable periods. The rates of evaporation in the various situations are plotted for four-week periods in fig. 24. The great difference between the rates in the top of the trees and those in the other situations is shown very clearly. The variations in the seasonal rates are similar to those for lower elevations.

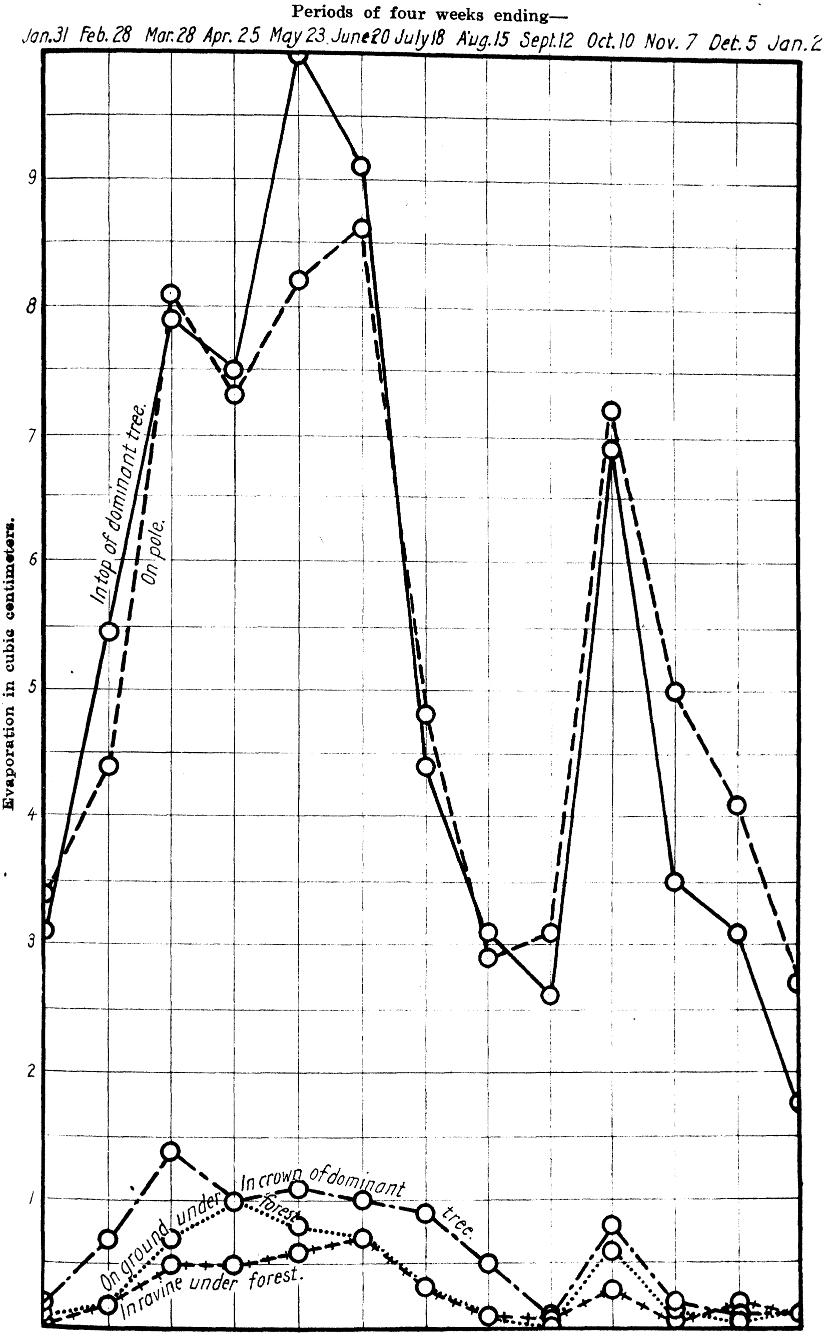

FIG. 24. Average daily rate of evaporation in different situations in mossy forest, Mount Maquiling; altitude, 1,050 meters.

EVAPORATION AT DIFFERENT ELEVATIONS

For convenience in comparing the rates of evaporation at different elevations, the average daily rates in the tops of the trees at these different elevations are brought together for four-week periods in Table CXLIII and are plotted in fig. 25. The

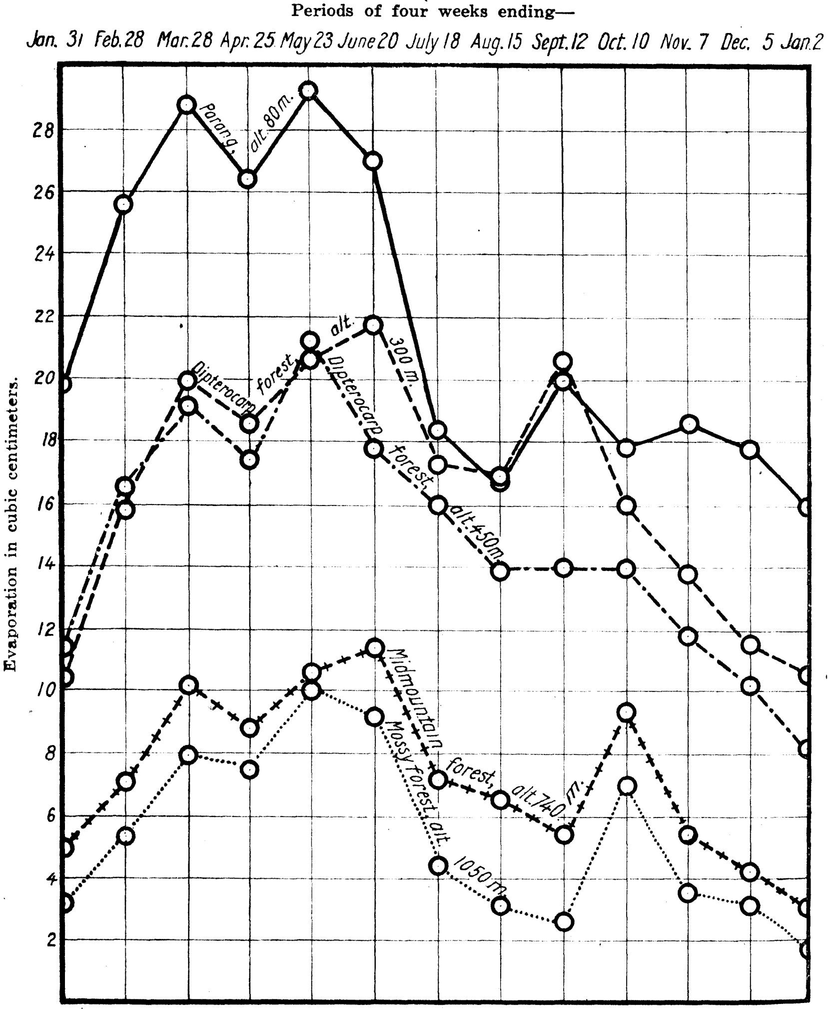

FIG. 25. Average daily rate of evaporation in the tops of dominant trees at different altitudes on Mount Maquiling.

rates near the ground are treated in a similar manner in Table CXLIV and fig. 26. An examination of fig. 25 shows that the curves for seasonal variations at different altitudes have very similar forms, which would indicate that these variations

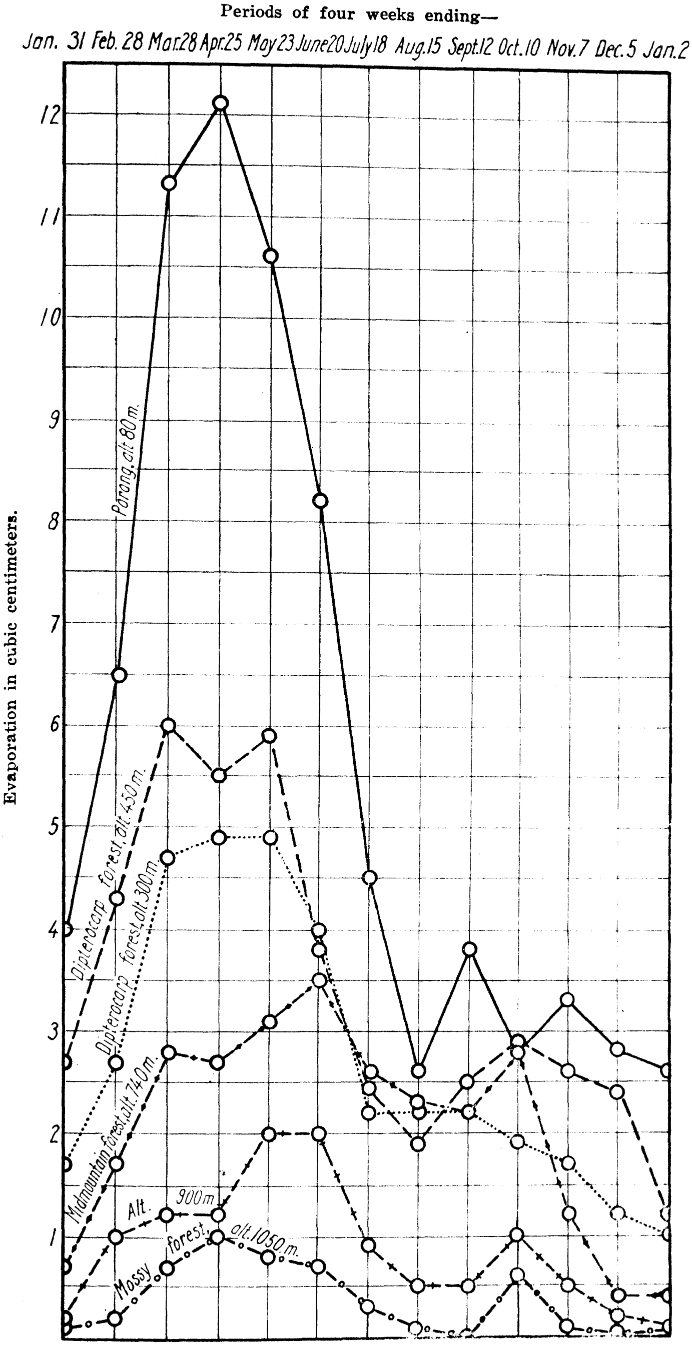

FIG. 26. Average daily rate of evaporation under the forest at different altitudes on Mount Maquiling.

TABLE CXLIII.—*Average daily evaporation for periods of four weeks in tops of dominant trees from October, 1912, to January, 1915, at different elevations on Mount Maquiling.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Four weeks ending—	Elevation in meters.				
	80.	300.	450.	740.	1,050.
January 31	19.7	10.4	11.2	4.9	8.1
February 28	25.5	15.8	16.5	7.1	5.4
March 28	28.7	19.9	19.1	10.1	7.9
April 25	26.4	18.6	17.4	8.8	7.5
May 23	29.2	20.6	21.2	10.6	10.0
June 20	26.9	21.7	17.7	11.3	9.1
July 18	18.4	17.2	16.0	7.1	4.4
August 15	16.7	16.9	13.9	6.6	3.1
September 12	19.9	20.5	13.9	5.4	2.6
October 10	17.9	15.9	13.9	9.3	6.9
November 7	18.5	13.8	11.8	5.4	3.5
December 5	17.7	11.5	10.1	4.3	3.1
January 2	15.9	10.6	8.0	3.0	1.7
Average	21.6	16.4	14.7	7.2	5.3

TABLE CXLIV.—*Average daily evaporation for periods of four weeks from October, 1912, to January, 1915, under the forest at different elevations on Mount Maquiling.*

[Numbers give evaporation in cubic centimeters from a Livingston atmometer.]

Four weeks ending—	Elevation in meters.					
	80.	300.	450.	740.	900.	1,050.
January 31	4.0	1.7	2.7	0.7	0.2	0.1
February 28	6.5	2.7	4.3	1.7	1.0	0.2
March 28	11.3	4.7	6.0	2.8	1.2	0.7
April 25	12.1	4.9	5.5	2.7	1.2	1.0
May 23	10.6	4.9	5.9	3.1	2.0	0.8
June 20	8.2	4.0	3.8	3.5	2.0	0.7
July 18	4.5	2.2	2.4	2.6	0.9	0.3
August 15	2.6	2.2	1.9	2.3	0.5	0.1
September 12	3.8	2.2	2.5	2.2	0.5	0.01
October 10	2.8	1.9	2.9	2.8	1.0	0.6
November 7	3.3	1.7	2.6	1.2	0.5	0.1
December 5	2.8	1.2	2.4	0.4	0.2	0.04
January 2	2.6	1.0	1.2	0.4	0.1	0.1
Average	5.8	2.7	3.4	2.0	0.9	0.4

are brought about by similar sets of factors in the different situations. It has been previously noted that the curves for rainfall, temperature, humidity, and light all show similar variations at different altitudes. Table CXLIII and fig. 25 show

very clearly that the average rates of evaporation decrease with rising elevations. This decrease in the rate of evaporation, accompanied by an increase in the moisture content of the soil, would certainly be sufficient to account for the greater development of herbaceous vegetation as higher elevations are reached. Likewise the decrease in evaporation, accompanied by the greater cloudiness, should account for the greater development of cryptogamic epiphytes at higher elevations.

An examination of Table CXLIV shows that the rate of evaporation near the ground under the forest also decreases steadily with increasing altitudes. A comparison of fig. 26 with fig. 25 shows that the rates vary in much the same way under the trees as in the tops of the trees. The difference in rates of evaporation at different elevations was relatively greater near the ground than in the tops of the trees, as will be seen by a comparison of Tables CXLIII and CXLIV. The rate in the tops of the trees in the mossy forest was 25 per cent of that in the top of the second-growth tree at the base, while the rate near the ground under the mossy forest was only 7 per cent of that under the second-growth trees at an elevation of 80 meters. The evaporation at the top of the trees in the mossy forest was 32 per cent of that in the dipterocarp forest at an elevation of 300 meters, while the rate near the ground in the mossy forest was 12 per cent of that near the ground in the dipterocarp forest at an elevation of 450 meters.

Shreve * repeatedly emphasizes the fact that in the rain forests of the Blue Mountains in Jamaica xerophytes and extreme hygrophytes may live together in the closest proximity. This is also more or less true of the vegetation at all altitudes on Maquiling. In the grass areas at the base a delicate *Riccia* and a *Selaginella* live on ground that is covered by coarse grasses. In the dipterocarp forest mesophytic ferns are found in the ravines, and very xerophytic epiphytes grow in the tops of the trees. In the midmountain forest the xerophytes again occur in the trees, and delicate, filmy ferns and liverworts in ravines. In the mossy forest orchids of xerophytic appearance are found near the tops of the branches, and filmy ferns, liverworts, and mosses on the trunks.

If we examine the rates of evaporation in the tops of the trees and in situations near the ground under the forest, it will be seen that the plants at the tops of the trees live in an

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* Shreve, F., A montane rain-forest, *Pub. Carnegie Inst. of Washington* (1914), No. 199.

environment which is very different from that under the forest. This is true as regards not only evaporation but also temperature, as the variations in temperature are much greater in the tops of the trees than under the forest.

The average rate of evaporation in the tops of the second-growth trees at the base of the mountain was seventy two times that in the ravine near the summit. So great a difference would seem to be sufficient to explain the differences in the epiphytes in the two situations. In the ravine near the summit there is an extensive development of delicate liverworts and filmy ferns, while in the parang epiphytes other than crustaceous lichens are almost entirely absent. It is interesting to note that even the small difference between the rate of evaporation near the ground on the ridge at the top of the mountain and that in the ravine near the top is accompanied by an evident difference in the epiphytic vegetation as delicate filmy ferns are much more developed in the ravine than on the ridge.

The difference in the rates of evaporation in the two situations just discussed is relatively much greater than that between the rate near the ground in mesophytic forests in the United States and in the open in the Arizona desert. Gates * found an average daily evaporation of 4.4 cubic centimeters in a beech-maple forest in Michigan. This is a lower rate than that observed in mesophytic forests by Fuller,† Transeau, ‡ or Weaver.§ Livingston ‖ gives the average weekly rate of evaporation at Tucson, Arizona, from May 25 to September 1, 1908, as 373 cubic centimeters. This is only twelve times as great as the low rate recorded by Gates. The rate in the tops of the trees in the mossy forest is eighteen times that in the ravine at the same elevation. In the dipterocarp forest at 300 meters' elevation the rate in the tops of the trees is eleven times that in the ravine.

While the effect of the different rates of evaporation on the

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* Gates, F. C., The relation between evaporation and plant succession in a given area, *Am. Journ. Bot.* (1917), **4**, 161–178.

† Fuller, G. D., Evaporation and soil moisture in relation to the succession of plant associations, *Bot. Gaz.* (1914), **58**, 193–234.

‡ Transeau, E. N., The relation of plant societies to evaporation, *Bot. Gaz.* (1908), **45**, 217–231.

§ Weaver, J. E., A study of the vegetation of southeastern Washington and adjacent Idaho, *University of Nebraska Studies* (1917), **17**, 1–133.

‖ Livingston, B. E., A study of the relation between summer evaporation intensity and centers of plant distribution in the United States. *Plant World* (1911), **14**, 205–222.

ground covering and on the development of epiphytes is fairly clear, it is not clear in regard to the height of the forests and rates of growth. It will be noted that both the height of vegetation and the rates of growth decrease with lower rates of evaporation. This is quite contrary to what has usually been observed to be the case with temperate vegetation. This point will be discussed later.

COMPARISON OF RATES OF EVAPORATION ON MOUNT MAQUILING WITH THOSE IN OTHER LOCALITIES

All of the rates of evaporation mentioned in the following discussion were obtained from a Livingston atmometer and reduced to the standard used by Livingston. With one exception the rates to be compared with those on Mount Maquiling appear to have been recorded by instruments not provided with rain-correcting attachments. There is no means of estimating the error thus introduced, but the rates for these localities would undoubtedly have been higher had they been taken in the same manner as were those for Mount Maquiling.

Fuller * found that the average daily rate of evaporation near the ground in a beech-maple forest in Indiana was 8 cubic centimeters. Transeau † observed an average daily rate of 8.5 cubic centimeters from June 6 to July 2, 1907, in a mesophytic forest on Long Island, New York. Weaver ‡ found the rate of evaporation in a *Thuja* climax forest only slightly greater (0.5 cubic centimeter daily in 1913) than Fuller's figures for the beech-maple forest of Indiana.

The rates of evaporation in a mesophytic forest in Florida have been measured by Gano and McNeill § with a Livingston rain-correcting atmometer, from January to May, 1913. The average daily rate for this period was 8.5 cubic centimeters, which is very similar to the results obtained in northern mesophytic forests by Fuller, Transeau, and Weaver. All of these rates are higher than the average daily rate under the second-growth forest at the base of Mount Maquiling, and several

* Fuller, G. D., Evaporation and soil moisture in relation to the succession of plant associations, *Bot. Gaz.* (1914), **58**, 193–234.

† Transeau, E. N., The relation of plant societies to evaporation, *Bot. Gaz.* (1908), **45**, 217–231.

‡ Weaver, J. E., A study of the vegetation of southeastern Washington and adjacent Idaho, *University of Nebraska Studies* (1917), **17**, 1–133.

§ Gano, L., and McNeill, J., Evaporation records from the gulf coast, *Bot. Gaz.* (1917), **64**, 318–329.

times as great as that under the dipterocarp forest. They are, moreover, considerably higher than the average for any four-week period in the dipterocarp forest. Fuller's figures for evaporation in the beech-maple forest indicate a rate twenty times as great as that under the mossy forest.

Fuller * found an average daily evaporation of 13.5 cubic centimeters at a height of 2 meters above the forest floor in a beech-maple forest in Indiana. This rate is much higher than that at the top of the trees at an elevation of 740 meters and is only 1.2 cubic centimeters less than the average daily rate in the top of the dominant tree at 450 meters' elevation. The rate observed by Fuller was practically twice that in the second-story tree at the latter elevation.

In a beech-maple forest in Michigan Gates † has found a much lower rate than any of those mentioned above. He says that the average daily rate for the normal density of this forest was 4.4 cubic centimeters. The highest average daily rate obtained in open ground was 14.7 cubic centimeters. The average daily rate under the forest was, however, considerably higher than that under the virgin forest at any elevation on Mount Maquiling. The rate in the open was very similar to that in the top of the tree at 450 meters' elevation.

The above comparisons would seem to indicate that the rates of evaporation under the forest on Mount Maquiling are much lower at all elevations, except under the second-growth forest, than in an average mesophytic temperate forest. The average daily rate of evaporation under the second-growth trees for the four-week periods ending March 28, April 25, and May 23, was 11 cubic centimeters, which is higher than any of the summer rates just mentioned for a mesophytic forest. It should be remembered, however, that a second-growth forest is very low and by no means a climax type. These high rates for the second-growth forest are similar to those obtained by Fuller ‡ during the summer months in an oak-dune association in Indiana, where the average for three seasons was 11 cubic centimeters, exactly the same as under the second-growth trees during the driest months.

* Fuller, G. D., Evaporation and the stratification of vegetation, *Bot. Gaz.* (1912), **54**, 424–426.

† Gates, F. C., The relation between evaporation and plant succession in a given area, *Am. Journ. Bot.* (1917), **4**, 161–178.

‡ Fuller, G. D., Evaporation and soil moisture in relation to the succession of plant associations, *Bot. Gaz.* (1914), **58**, 207.

Livingston * gives the rate of evaporation at a number of stations in the United States for the period from May 25 to September 7, 1908. He says:

> The deciduous forest of the middle east occupies a region with over 100 cc., often over 150 and even 200 cc., as the mean weekly summer rate.

These rates were obtained in the open with the center of the cups 15 centimeters above the soil surface. The average weekly rates in the two open areas at the base of Mount Maquiling were, respectively, 103 and 138 centimeters. This comparison would indicate that the rate of evaporation at the base of Mount Maquiling is similar to that in the deciduous forest region of the middle east.

Shreve † measured the rate of evaporation in three stations in a montane forest in the Blue Mountains of Jamaica at an elevation of about 1,525 meters. One of the stations was in the open at Cinchona, another on a forested ridge, and the third in a forested ravine. The average daily evaporation in the ravine for the period from September 6 to October 11, reduced to Livingston's standard, was 0.6 cubic centimeter, which is somewhat less than the average daily rate for the ravine in the midmountain forest at an elevation slightly below 740 meters. Brown ‡ also measured the evaporation from May 22 to June 16, 1910, in the same ravine in Jamaica with a rain-correcting atmometer and found an average daily rate of 0.77 cubic centimeter. This figure is larger than Shreve's. Shreve's instrument did not have a rain-correcting attachment but was protected from rain by a glass plate, which did not, however, protect it from the fogs, and so Shreve's rate may be slightly too low. The average rate obtained by Brown is greater than the average rate in the ravine in the midmountain forest of Mount Maquiling. While Brown's and Shreve's records in Jamaica cover too short a period to make them strictly comparable with the records on Maquiling, it seems not improbable that the rates in the ravine in the Jamaican forest and in the midmountain forest are very similar. Shreve found an average daily evaporation on the forested ridge of 3 cubic cen-

* Livingston, B. E., A study of the relation between summer evaporation intensity and centers of plant distribution in the United States, *Plant World* (1911), 14, 205–222.

† Shreve, F., A montane rain-forest, *Pub. Carnegie Inst. Washington* (1914), No. 199.

‡ Brown, W. H., Evaporation and plant habitats in Jamaica, *Plant World* (1910), 13, 79–82.

timeters. This is a higher daily rate than was observed near the ground in the virgin forest on Mount Maquiling, except in the dipterocarp forest at an elevation of 450 meters, where the average daily rate was 3.4 cubic centimeters. The average of the two stations in the dipterocarp forest gives practically the same rate as Shreve's figures give for the forested ridge in the Blue Mountains of Jamaica. In the open at Cinchona Shreve's figures give an average daily rate of 6.8 cubic centimeters for the period between June 20 and November 22. Brown's figure for the same station for the period between May 22 and June 16 was 8.2. From these figures it would appear that the rate in the open at Cinchona is not very different from the rate in the tops of the trees at an elevation of 740 meters, or the rate near the ground in the opening in the dipterocarp forest at an elevation of 450 meters. According to these figures it would appear that the rates obtained by Shreve are higher than those in the midmountain forest, except in the ravine. According to the writer's recollection the physical type of the forest on the Blue Mountains of Jamaica at an elevation slightly greater than 1,500 meters is more similar to that of the midmountain than any of the other forest formations on Mount Maquiling. In very damp ravines, however, the mossy covering in the Jamaican forest approaches that in the mossy forest on Mount Maquiling. In the montane forest in Jamaica fogs are of very frequent occurrence; a fact that is emphasized by Shreve as having great influence on the vegetation. It seems not unlikely that these frequent fogs are largely responsible for the mossiness of the forest in the wet ravines.

The rates of evaporation in the montane forest of Jamaica, according to the records of Shreve and Brown, do not appear to be anything like as low as the rates in the mossy forest on Mount Maquiling. Concerning the humidity in the Jamaican forest Shreve says:

> After repeated observations with the hygrograph and sling psychrometer, I am convinced that saturation, or even humidities as high as 97 to 99 per cent, are extremely transitory states of the atmosphere in the most moist situations in the rain-forest. Saturation must precede precipitation; and the condensation of moisture on the foliage of plants often takes place in the deep forest. As soon as precipitation or condensation occurs, there is a fall in the humidity and it naturally rises again but slowly, for although the extent of wet surfaces capable of adding by evaporation to the moisture of the air is very great, the high humidity itself retards such evaporation. Cloudiness is an important factor in influencing humidity as well as is fog. The passage of small clouds over the face of the sun

causes immediate and pronounced rises in humidity, due in great measure to the sudden fall of temperature which may be too transitory to affect the sluggish thermograph.

In the midmountain forest of Mount Maquiling, although the humidity is high, the air is probably seldom saturated, but in the mossy forest the atmosphere under the forest appears to be practically saturated a large part of the time. From my own observations in Jamaica and on Mount Maquiling, and from Shreve's discussion of the forest in Jamaica, I am convinced that fogs are of much more frequent occurrence and persist for very much longer periods near the top of Mount Maquiling than in the forest on the Blue Mountains in Jamaica. The much lower rate of evaporation in the mossy forest of Mount Maquiling than that obtaining in the Jamaican montane forest as well as the greater prevalence of fogs in the former location probably account for the fact that the mossy covering has developed near the summit of Mount Maquiling, even on the ridges, to an extent approached only in the moister ravines in the Jamaican forest.

It may be of interest to compare the lowest rate of evaporation observed on Mount Maquiling with high rates reported from the United States. According to Livingston,* the average weekly rate of evaporation at Tucson, Arizona, from May 25 to September 1, 1908, was 373 cubic centimeters. This is one hundred seventy-eight times as great as the average rate in the ravine in the mossy forest near the top of Mount Maquiling. The average weekly rate at Reno, Nevada, for seven weeks between June 29 and September 1, 1908, was, according to Livingston, 437 cubic centimeters. This is two hundred eight times the average rate in the ravine near the top of Mount Maquiling. The rate in Arizona is seventy-seven times that in the ravine in the midmountain forest on Mount Maquiling. This ratio is only slightly greater than that between the rate of evaporation in the ravine in the mossy forest of Mount Maquiling and that at the top of the second-growth tree, the latter being seventy-two times as great as the former.

The relation of evaporation to plant succession has of late received considerable attention. Fuller,† as a result of his

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* Livingston, B. E., A study of the relation between summer evaporation intensity and centers of plant distribution in the United States, *Plant World* (1911) 14, 205–222.

† Fuller, G. D., Evaporation and soil moisture in relation to the succession of plant associations, *Bot. Gaz.* (1914), 58, 193–234.

studies in Indiana, says that the variations in evaporation in different types of vegetation were great enough to be efficient factors in causing succession. Weaver, * in discussing the vegetation of southeastern Washington and adjacent Idaho, says:

> A study of the differences of the rates of evaporation in the various plant communities shows that these differences are sufficient to be important factors in causing succession, at least through the earlier stages, where light does not play an important rôle.

Gates † has studied the rates of evaporation in a limited area in Michigan. The rates here were apparently lower than those dealt with by Fuller and Weaver. Concerning the effect of evaporation on vegetation Gates says:

> The complete range of evaporation conditions present in this region, namely, from bare ground to the mature forest, is completely within the physiological limits of the seedlings of *Acer saccharum, Pinus strobus, Pinus resinosa,* and *Thuja occidentalis.* Given suitable soil conditions, maple seedlings will develop under evaporation conditions at least 337 per cent more xerophytic than the normal hardwood forest, or 400 per cent more xerophytic than the very dense forest.

From this he concludes that the changes in the rates of evaporation due to vegetation are not essential for succession.

At the base of Mount Maquiling where the original forest has been removed there are evidences that the area was originally covered by a tall dipterocarp forest. In the area are scattered large individuals of *Parashorea malaanonan* which regularly produce large numbers of seeds, but these do not grow into seedlings even in the second-growth forest. In the same area Dr. F. W. Foxworthy has attempted to grow seedlings of *Parashorea* and other dipterocarps in plantations, but without success. However, as might be expected, such seedlings did grow at slightly higher elevations within the dipterocarp forest. From these observations it would appear that *Parashorea* seedlings cannot succeed in the cleared area formerly occupied by this species. The most obvious explanation of this would seem to be that the high evaporation rate and low moisture content of the soil, resulting from the removal of the dense forest, are at least the chief factors in killing the seedlings of *Parashorea* and, further, that a fairly dense forest must be established in this area before the dipterocarps can enter. In this case it would seem that a low rate of evapo-

* Weaver, J. E., A study of the vegetation of southeastern Washington and adjacent Idaho, *Univ. Nebraska Studies* (1917), 17, 36.

† Gates, F. C., The relation between evaporation and plant succession in a given area, *Am. Journ. Bot.* (1917), 4, 161–178.

ration caused by a forest cover may be instrumental in producing further succession.

On Mount Mariveles the forest has been removed at an elevation of 500 meters. This area appears to be much moister than that at the base of Mount Maquiling. The dipterocarp seeds that have been scattered over the cleared area succeed well, and have produced vigorous plants which grow rapidly and look as though they would reach maturity.

The evaporation conditions in the open on Mount Mariveles at an altitude of 500 meters are not severe enough to exclude seedlings of the dominant species of the dense forest. It would appear, therefore, that in some cases either a lower rate of evaporation or a higher moisture content of the soil, or probably both, resulting from the growth of vegetation, may be efficient factors in succession while in other cases a lower rate of evaporation is not essential. The two cases just mentioned have been discussed at some length by Brown and Matthews.*

RELATION OF EVAPORATION TO VEGETATION

On Mount Maquiling the best-developed vegetation is found at the base of the mountain, and the poorest, at the top; in other words, among the natural climax types the best-developed vegetation occurs in a situation where there is the highest evaporation, and the poorest, where there is the lowest. This is quite different from conditions ordinarily found in temperate countries, where the tall climax types occur in situations with the lower rates of evaporation. One of the most prominent features of the vegetation is the change from desert to prairie, and then to forest, with decreasing rates of evaporation. Fuller † found that, as vegetation developed from dune associations to the beech-maple forest, the rate of evaporation decreased. Weaver ‡ has also found a decreasing rate of evaporation from the desert scrub formation to the climax cedar forest. On Mount Maquiling, however, as has been previously pointed out, the rates of evaporation even in the dipterocarp forest appear to be lower than in the mesophytic forest of the United States.

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* Brown, W. H. and Matthews, D. M., Philippine dipterocarp forests, *Phil. Journ. Sci., Sec. A* (1914), **9**, 413–561.

† Fuller, G. D., Evaporation and soil moisture in relation to the succession of plant associations, *Bot. Gaz.* (1914), **58**, 193–234.

‡ Weaver, J. W., A study of the vegetation of southeastern Washington and adjacent Idaho, *Univ. Nebraska Studies* (1917), **17**, 1–133.

It seems to be the general consensus of physiologists that the transpiration stream is very important for the movement of dissolved salts from the roots to the leaves of plants. This opinion is expressed very clearly by Pfeffer * and by Jost.† Burgerstein ‡ emphasizes this view in a critical discussion of work done previous to the publication of his book, and he seems to have shown very clearly that the earlier work presented no conclusive evidence in favor of the view that transpiration was a necessary evil. Barnes, § while admitting the possibility that transpiration is of advantage for the transport of mineral salts, was inclined to the view that it is a necessary evil. He makes the following statement:

> In the rain forests of Ceylon (and doubtless elsewhere) there are regions of luxuriant vegetation where for months at a time the rain ceases only to be replaced by a mist. In such conditions evaporation is almost impossible. It cannot, therefore, be necessary to an adequate supply of solutes in the soil.

This is not in agreement with what the writer has been able to learn from his own observations and from descriptions of forests in the Malayan region.

Hasselbring ‖ has found that tobacco plants growing under shade transpire less, but give more ash, than plants growing in the open. This writer was evidently working with comparatively high rates of evaporation. In another paper ¶ he says that tobacco plants in the open transpired more than those under shade, but that the total amount of dry substance produced was practically the same in both cases. These experiments were also performed with comparatively high rates of evaporation. Very high rates of evaporation and low percentages of moisture in the soil are undoubtedly detrimental to vegetation, but it does not follow from this that very low rates of evaporation might not also be unfavorable. The present status of this

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* Pfeffer, W., The Physiology of Plants. English translation by A. J. Ewart. Oxford (1900).

† Jost, L., Lectures on Plant Physiology. English translation by R. J. H. Gibson. Oxford (1907).

‡ Burgerstein, Die Transpiration der Pflanzen. Jena (1904).

§ Barnes, C. R., in Coulter, Barnes, and Cowles, Text Book of Botany (1910), 317.

‖ Hasselbring, H., The relation between the transpiration stream and the absorption of salts, *Bot. Gaz.* (1914), 57, 72–73.

¶ Hasselbring, H., The effect of shading on the transpiration and assimilation of the tobacco plant in Cuba, *Bot. Gaz.* (1914), 57, 257.

question seems to be very well summed up in the following quotation from Livingston: *

The question as to what rates of transpiration are necessary to elevate the requisite amount of salts in tall plants deserves further attention at the hands of experimenters. It appears clear enough, on *a priori* grounds, that *some* transpiration must generally give better growth than none at all, but the rates generally experienced by ordinary plants are probably much higher than the optimum.

The rate of transpiration depends, of course, in a large measure, upon the evaporating power of air. Shreve, † who made a very detailed study of transpiration rates in the montane rain forest of Jamaica, found, as pointed out previously, that the rate of evaporation was very low in this forest and that the rate of transpiration was also extremely low. In comparing the rates found in the forest in Jamaica with those of plants in Arizona, he says:

* * * The rates of relative transpiration in Jamaican rain-forest plants and in plants of the Arizona desert are found to be of the same general order of magnitude. This is merely saying that the rates of transpiration in the two regions are proportional to the rates of evaporation which prevail in them. While the plants of the rain-forest are capable of losing much more water per unit area than are the plants of the desert if the two kinds of plants are brought under the same conditions, it is nevertheless true that as each set of plants exists, under its own climate, the desert plant loses far more water in transpiration per unit area than does the plant of the rain-forest.

It has, of course, been clearly established that high rates of evaporation are harmful to plants; but, in order that there may be any transpiration, there must be an appreciable rate of evaporation. It would seem, therefore, that there may be minimum and optimum rates of evaporation for plant growth, even though the optimum rates may be comparatively low. Such low rates as occur at high elevations on Mount Maquiling may be below the optimum; but, in view of the present state of our knowledge, we can only speculate concerning this point. Still, it may be of interest to compare the rates of evaporation with the heights of the trees at different elevations on Mount Maquiling. Such a comparison is made in Table CXLV. In the second column of Table CXLV the average rates of evaporation in the tops of the dominant trees are given in centimeters, and

* Palladin, V. I., Plant Physiology, edited by B. E. Livingston. Philadelphia (1918), 136.

† Shreve, F., A montane rain-forest, *Pub. Carnegie Inst. Washington* (1914), No. 199.

the last column gives the heights of the trees. In order to have the evaporation rates of the same general magnitude as the heights of the trees, they have been multiplied by 2.64 and the results given in column 3. The figures in column 3 are in fairly close agreement with the heights of the vegetation, although not so close as the ratios of the temperature-light indices. It is very natural that evaporation should show the same general sort of curve as the temperature-light indices, as temperature and light are largely responsible for the differences in rates of evaporation at different elevations on Mount Maquiling. The general agreement between the ratios of evaporation and the heights of trees may, therefore, be accidental.

If we were to assume that the rates of evaporation in the virgin forest are below the optimum and that the size of the trees would be directly proportional to the rate of evaporation, then the differences in the rates of evaporation at the different elevations would be sufficient to account for the differences in the heights of the trees, except perhaps at an altitude of 740 meters. However, if we attempt to explain the heights of the vegetation as due to evaporation, it would be necessary to assume that the evaporation rates at 80 and 300 meters are higher than the optimum and high enough to be detrimental; otherwise, there would be no explanation of the fact that at these elevations the ratios for the heights of vegetation are much lower than those for evaporation. In comparing the ratios of the temperature-light indices with the height of the vegetation, it has been shown that the temperature-light ratios are also higher than those for the vegetation at the lower elevations.

TABLE CXLV.—*Comparison of evaporation rates and heights of vegetation at different elevations on Mount Maquiling.*

Altitude.	Average daily evaporation.	Average daily evaporation × 2.64.	Height of trees.
Meters.	*cc.*		*Meters.*
80	21.6	57.0	----------
300	16.4	42.7	38
450	14.7	39.8	36
740	7.2	19.0	22
1,050	5.3	14.0	8-14

A very logical explanation of the heights of the vegetation at different elevations is obtained if we assume that the de-

crease in the height of the trees with increasing elevations is due to decreasing temperature and light intensity, and that the rates of evaporation at 80 and 300 meters are too high for the best development of the vegetation and so account for the fact that the trees in the lower part of the dipterocarp forest are not so tall as would be indicated by the temperature-light indices.

The rates of evaporation at the highest elevations may be too low for rapid growth, and may have some effect in causing the dwarfing of vegetation; but, as before mentioned, we have no real evidence on which to base an opinion. A combination of temperature, light intensity, and evaporation rates would certainly seem to be sufficient to account for the observed differences in vegetation, and it might perhaps be more reasonable to ascribe to differences in temperature and light rather than to evaporation at least the major part, if not all, of the variations in the height of the vegetation. This is particularly so, since the high rates of evaporation in the dry season appear to have a very decidedly detrimental influence on the vegetation in the parang and in the dipterocarp forest. As will be shown later, it is during the dry season that trees at the base of the mountain make their slowest growth. At this time many of the second-growth trees are deciduous for a considerable period. *Parashorea malaanonan* at an elevation of 300 meters also makes its slowest growth during the dry season; and at this time, though the trees are not deciduous, the foliage is much less dense than at other times. During the dry season the ground in the dipterocarp forest, particularly in the lower part, is literally covered with dead leaves.

The writer has made too few measurements of seasonal growth in the midmountain and mossy forests for them to be conclusive, but those made seem to point to the conclusion that trees near the top of the mountain also grow more slowly during the dry season than at other times.

The moisture conditions on the ridges in the dipterocarp forest would appear to be unfavorable for the development of herbaceous plants. In the discussion of vegetation it was shown that such plants were scarce on the plots in the dipterocarp forest and very abundant in the midmountain forest. In the dipterocarp forest at an elevation of about 500 meters there is a very considerable development of various species of *Elatostema*. These are small herbaceous plants, and in this region they frequently cover the ground over considerable areas, even on the ridges. During the dry season all of the plants of these

species on the ridges at elevations slightly above 500 meters are very frequently found wilted. Evidently at such times the combination of the relatively low moisture content of the soil and the relatively high evaporation rates is unfavorable for these species. As they frequently wilt at high elevations in the dipterocarp forest, it is not surprising that they do not occur on the ridges at low altitudes, as the soil moisture decreases and evaporation increases at lower elevations.

As previously mentioned, the dipterocarp forest is much better developed in regions where there are no distinct wet and dry seasons and where there is an evener distribution of rainfall than prevails on Mount Maquiling.

The dry season certainly has a very detrimental effect on cultivated plants at elevations of from 50 to 80 meters. Good growth can only be obtained during this season by means of irrigation.

There thus appears to be considerable evidence to indicate that at least during the dry season the rate of evaporation in the dipterocarp forest is too high for the best development of plants. This question will be considered again in discussing seasonal rates of growth.

The effect of evaporation on the ground covering and on the epiphytic vegetation has been discussed previously.

WIND VELOCITY

The velocity of the wind at different elevations on Mount Maquiling was measured by gauges obtained from Julien P. Friez, Baltimore, Maryland. The type of instrument used was operated by four cups, so placed as to catch the wind from any direction. The instrument used read only a thousand miles; as the wind frequently exceeded that rate within a week, particularly at the higher altitudes, it was impracticable to obtain weekly readings at all elevations. However, a sufficient number of comparisons were obtained at different elevations to indicate that wind velocity, as might be expected, increases with altitude.

Daily readings were taken in the top of a second-growth tree in the parang from July, 1913, to January, 1915. The instrument was elevated on a pole so as to expose it above the foliage. The results of the daily readings are given in Table CXLVI and are summarized for corresponding four-week periods in Table CXLVII. The latter figures are plotted in fig. 27. An examination of this figure shows that there were two periods of high wind velocity; one during the dry season and due

TABLE CXLVI.—*Daily wind velocity at the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give wind velocity in miles.]

Date.	July.	August.	September.	October.	November.	December.
1913.						
1		82.0	113.7	58.8	61.7	158.2
2	62.9	88.0	72.0	59.4	89.7	87.0
3	33.7	83.0	79.4	80.2	84.5	109.0
4	48.8	62.5	355.0	69.7	90.8	29.3
5	46.3	55.2	266.5	90.2	45.0	79.1
6	118.1	77.8	219.7	65.8	67.6	62.3
7		78.5	107.6	62.0	104.2	100.3
8	65.8	91.0	56.2	16.7	83.4	100.3
9	53.4	98.4	148.7	108.9	85.6	112.1
10	54.7	136.7	191.4	58.2	99.7	130.4
11	56.3	95.9	99.5	136.6	94.9	117.3
12	32.0	64.4	143.3	61.5	110.2	88.2
13	6.6	63.3	73.6	55.5	111.5	87.7
14	107.4	104.1	83.5	338.0	96.7	97.6
15	66.2	10.9	116.7	89.5	109.9	101.5
16	137.3	29.8	198.3	106.5	180.1	51.7
17	115.9	73.0	92.7	41.3		87.8
18	86.8	8.5	91.1	113.7	84.8	156.5
19	65.0	36.1	70.2	87.4	79.4	47.0

TABLE CXLVI.—*Daily wind velocity at the base of Mount Maquiling; altitude, 80 meters*—Continued.

Date.	July.	August.	September.	October.	November.	December.
1913.						
20	98.7	115.1	74.7	78.2	75.3	94.1
21	70.2	56.3	53.1	71.0	71.0	95.9
22	59.0	66.2	81.7	64.9	107.2	71.5
23	70.7	54.6	81.3	73.7	104.3	66.3
24	68.5	77.4	56.7	95.6	120.7	47.4
25	62.0	45.3	74.1	113.8	113.9	181.1
26	112.1	98.7	107.5	101.4	81.0	
27	91.6	129.8	36.8	74.0	102.9	140.2
28	71.6	79.8	53.6	131.0	118.2	190.8
29	104.8	63.1	79.9	56.4	62.7	
30	268.2	52.6	63.3	101.3	----------	114.3
31	174.8	67.5	----------	91.8	----------	97.5
Average	80.3	72.4	111.4	88.8	90.9	88.5

Date.	January.	February.	March.	April.	May.	June.
1914.						
1	127.1	92.7	209.4	102.4	172.5	88.1
2	109.8	91.6		124.6	44.9	161.3
3	103.8	93.2	126.2	134.2	101.8	182.3
4	140.4	119.2	168.7	77.3	98.8	109.1
5	105.7	76.1	67.0	174.2	121.9	125.3
6	80.6	80.7	124.8		91.2	94.7
7	59.2	133.8	113.8	80.0	85.5	81.3
8	75.7	157.0	84.6	66.7	103.6	65.3
9	128.3		86.4	138.6	107.6	68.1
10	195.1	112.4	95.2	98.2	112.5	57.8
11	103.6	102.4	119.5	102.8	44.9	67.4
12	87.4	123.7	114.9	99.0	66.9	62.7
13	96.9	88.1	80.6	97.1	106.8	43.8
14	88.8	99.1	90.1	86.4	109.0	78.5
15	90.2	99.6	184.2	62.7	115.4	290.3
16	130.5	138.1		62.4	89.4	
17	155.3	153.7	160.2	77.4	75.1	
18	206.2	65.9	112.9	83.1	82.2	
19		18.6	120.6	176.7	76.0	220.2
20	69.7	124.2	138.2		88.1	220.2
21	82.6	196.2	80.8	56.0	61.8	147.0
22	97.7	216.1	109.3	130.3	114.0	
23	107.6		99.5	865.6	41.9	57.6
24	97.2	74.7	123.2	299.7	137.2	83.6
25	83.7	80.7	120.0	81.5		59.2
26	271.4	80.9	117.5	154.3	67.8	87.4
27		72.3	128.1		72.5	34.7
28		131.2	144.6	86.8	79.4	67.0
29	226.6	----------	308.4	91.0	61.4	92.5
30	78.2	----------		114.0	68.8	99.5
31	128.3	----------	85.0	----------	70.1	----------
Average	107.3	100.8	113.3	124.1	86.1	89.4

TABLE CXLVI.—*Daily wind velocity at the base of Mount Maquiling; altitude, 80 meters*—Continued.

Date.	July.	August.	September.	October.	November.	December.
1914.						
1	51.3	109.0	167.4	68.7	128.9	73.0
2	50.1	49.6	159.8	63.7	65.7	76.6
3	77.5	60.6	109.2	60.8	102.8	58.0
4	56.1	51.3	62.4	64.1	77.1	86.8
5	212.3	67.1	136.8	36.5	40.2	62.9
6		57.4	195.6	68.2	64.7	42.2
7	276.3	54.9	219.3	40.4	65.3	51.2
8	276.0	51.2	126.3	78.7	5.3	136.6
9	119.4	92.0	101.2	49.9	102.7	91.2
10	109.5		90.6	64.6	28.1	85.7
11	10.5	46.9	195.1	85.3	103.6	93.6
12	756.5	239.3	123.2	81.3	108.2	101.7
13			42.5	47.9	70.8	62.7
14	203.0	128.3	55.7	80.3	76.4	105.6
15	89.0	66.2	67.8	73.3	61.9	97.7
16	50.0	65.4	60.0	70.5	98.6	68.8
17	56.7	54.4	64.3	62.4	67.8	51.7
18	57.3	105.8	44.3	59.4	46.2	81.7
19	39.9	60.2	67.2	71.3	100.6	74.4
20	51.7	41.6	72.1	57.9	55.4	113.2
21	106.6	195.4	78.9	62.2	67.1	78.2
22	2.8	199.2	64.2	50.3	72.9	63.8
23	57.0	131.1	44.4	109.2	79.0	49.8
24	49.7	71.3	71.4	104.7	70.4	71.2
25	70.9	167.6	112.7	83.3	62.2	65.7
26	140.6	283.1	22.1	170.8	94.1	55.1
27	114.3	305.2	69.6	102.8	84.3	106.8
28	60.5	339.8	51.4	82.9	84.7	85.5
29	81.4	284.7	57.1	62.4	121.1	101.1
30	75.8	393.6	64.2	93.6	66.5	98.8
31	47.2		--------	115.4	--------	74.1
Average	108.1	121.7	93.2	74.9	75.8	79.5

to the northeastern monsoon, and the other during the period ending September 11, which is in the typhoon season. From Table CXLVI it will be seen that the high average velocity during the latter period was due to comparatively short intervals of heavy winds, which occurred during typhoon weather. The high average velocity during the dry season is a result of fairly constant, high daily velocities during the season of the northeastern monsoon.

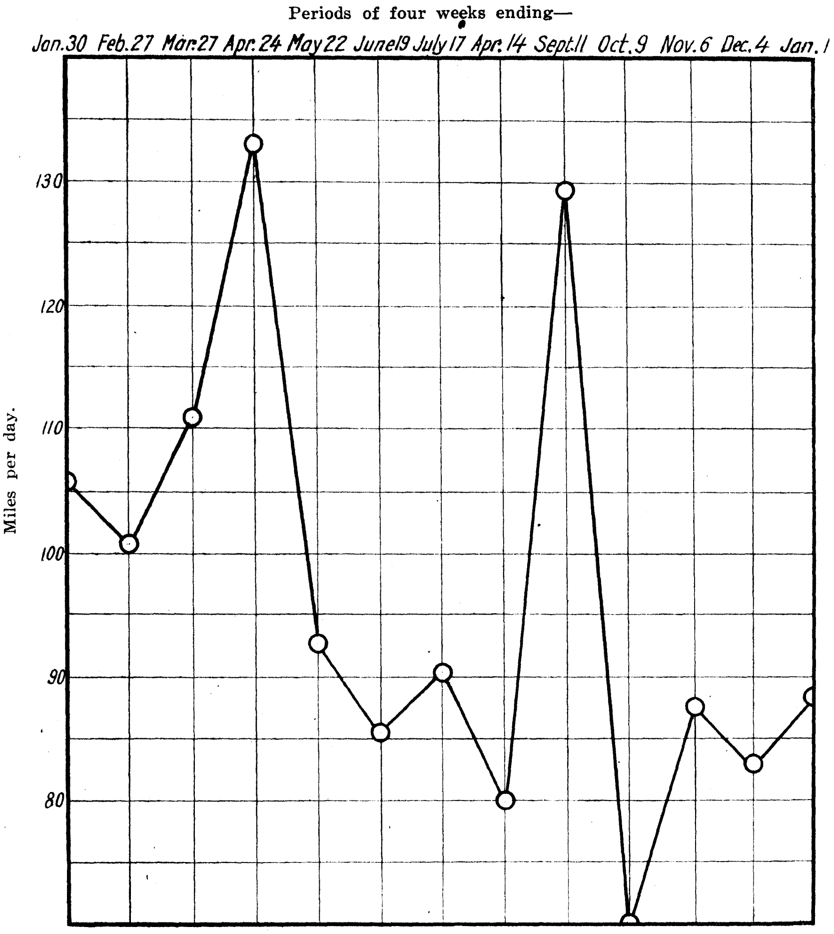

FIG. 27. Average daily wind velocity at the base of Mount Maquiling; altitude, 80 meters.

The most obvious effects of wind on vegetation are due to the increased evaporation resulting from high wind velocity. An examination of the tables for evaporation shows that at the base of the mountain the highest daily evaporation rates in the tops of the trees occurred simultaneously with some of the high wind velocities that were due to typhoons. The highest average rate of evaporation, however, occurred during the period of the northeastern monsoon when the daily wind velocity was constantly fairly high.

There is no evidence that the trees on Mount Maquiling are injured by the mechanical action of the wind, except that leaves are torn off during typhoons. The writer has observed the effects of a number of typhoons and has always found that the

greatest damage due to wind occurred in the dipterocarp forest and not at high elevations, although of course there may be times when the reverse is the case. Since the high wind velocities at the greater altitudes do not cause high rates of evaporation, there is little reason for assuming that differences in wind velocities have any marked influence in producing the dwarfing found near the top.

TABLE CXLVII.—*Average daily wind velocity for periods of four weeks, from July, 1913, to January, 1915, at the base of Mount Maquiling; altitude, 80 meters.*

Four weeks ending—	Miles.
January 30	105.8
February 27	100.7
March 27	111.0
April 24	133.4
May 22	92.8
June 19	85.5
July 17	90.4
August 14	79.9
September 11	129.2
October 9	70.1
November 6	87.5
December 4	82.9
January 1	88.2
Average	96.7

The high wind velocities at the summit of the mountain are probably responsible for the fact that hydrophytic epiphytes are not so well developed in the tops of the trees as on the trunks. The effect of high evaporation on epiphytic vegetation is very evident where an opening occurs in the canopy, as in such places the hydrophytic epiphytes die when exposed to the wind. The greatest development of epiphytes occurs, however, near the top of the mountain where the wind velocities are greatest. While the high wind velocity at the top of the mountain would tend to cause rapid evaporation, the very moist condition of the air counteracts this tendency to such an extent that the rate of evaporation is, as we have seen, very low.

INTERRELATION OF ENVIRONMENTAL CONDITIONS

Seasonal changes in environmental conditions in the Mount Maquiling region can be traced to wind direction and the position of the sun. The northeastern monsoon strikes the Islands on the western coast and deposits a large part of its moisture on the divide between Laguna de Bay and the Pacific Ocean before it reaches Mount Maquiling. The result is that when it does reach Mount Maquiling it is a drying wind and produces a distinct dry season, which is most pronounced from February to May. The southwestern monsoon is not nearly so strong a wind, and a large part of the rain that falls at this season of the year is the result of cyclonic disturbances (typhoons). During this monsoon rains are deposited on all parts of the Islands, and at this time there is in the Mount Maquiling region a distinct rainy season, when the skies are overcast by clouds for a considerable portion of the time. The season of heaviest rains is usually from July to September.

Light intensity is influenced greatly by the degree of cloudiness. The sun is overhead during the latter part of April and again about the middle of August. Between April and August it is in the north and is farthest south in the latter part of December. If the degree of cloudiness were the same at all times, we would expect two periods of maximum insolation, coincident with the times when the sun is overhead; and a period of minimum insolation during December. During the latter part of April, when the sun is overhead, the dry season is at its height, and this is the period of maximum insolation. When the sun gets to be farther north, the light intensity naturally decreases. The return to the overhead position does not, however, bring an increase in light intensity, as by this time the rainy season has set in, and instead of an increase in the intensity there is a decrease until the latter part of the rainy season. After the passing of the cloudiness that accompanies the rainy season, there is a rise in light intensity, followed by a fall as the sun gets to be still farther south, the average intensity reaching a minimum during the latter part of December, when the sun is farthest south.

The temperature follows the light intensity fairly closely. The highest temperatures occur during the dry season, when the light is most intense. After this the temperature decreases

until the latter part of the rainy season, when there is a slight rise, coincident with the rise in light intensity. Following this there is another fall until the end of the year, when the light intensity is lowest.

The rate of evaporation is greatest about April, during the height of the dry season, when light intensity and temperature are both high. The rate falls during the rainy season but does not reach a minimum until the end of the year, when the temperature and light intensity are both at a minimum. It thus appears that temperature and light intensity have more effect on the rate of evaporation than does the amount of rainfall.

Humidity is lowest in the dry season and highest at the end of the year, when the light intensity and temperature are both low. Thus humidity, like evaporation, appears to be regulated more by temperature and light intensity than by rainfall.

The seasonal variations in the environmental conditions are similar at all altitudes; although, of course, the intensity of various factors varies at different elevations.

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SEASONAL RATES OF GROWTH

Measurements of rates of growth for various seasons were made on a number of the same trees that were used for yearly measurements. In making the seasonal measurements it was not practicable to use similar periods in every case; and so, in order to have the results for different lengths of time comparable, all of the rates of growth have been calculated for periods of thirty days. All the measurements of seasonal growth, like those of annual growth, are diameter measurements. Rates of diameter growth are probably as good measurements of rates of growth of trees as the rates of any other single dimension, and it is of course impracticable to get the total growth of trees. The seasonal rates of growth do not, however, necessarily represent the actual amount of material manufactured in the period concerned. This objection does not appear to be nearly so serious in the case of tropical as it would be for temperate-zone trees; but it must be borne in mind that there may be periods when trees are accumulating and storing food much more rapidly than is indicated by the growth of any single dimension.

SEASONAL GROWTH IN THE PARANG

Seasonal measurements of diameter growth were taken on the small specimens of *Parashorea* growing in the open at an elevation of about 100 meters. The results are presented in Table CXLVIII and are plotted for different diameter classes in fig.

TABLE CXLVIII.—*Seasonal diameter growth of Parashorea malaanonan (bagtican lauan) in the open at the base of Mount Maquiling; altitude, about 100 meters.*

[Rates of growth are reduced to rates in centimeters for 30 days.]

Diameter.	Jan. 29 to Mar. 26.	Mar. 26 to Apr. 29.	Apr. 29 to June 2.	June 2 to July 24.	July 24 to Oct. 13.	Oct. 13 to Dec. 10.	Dec. 10 to Jan. 29.
cm.							
4.95	0.000	0.000	0.029	0.074	0.095	0.073	0.069
4.175	0.010	0.013	0.029	0.054	0.089	0.000	0.045
4.14	0.016	0.000	0.070	0.073	0.073	0.032	0.025
3.60	0.092	0.029	0.086	0.156	0.150	0.108	0.000
3.74	0.016	0.029	0.070	0.092	0.064	0.083	0.051
4.29	0.025	0.000	0.111	0.137	0.229	0.089	0.175
3.30	0.010	0.000	0.029	0.045	0.080	0.057	0.045
4.625	0.016	0.013	0.210	0.019	0.000	0.057	0.045
3.43	0.000	0.013	0.057	0.073	0.010	0.000	0.026

TABLE CXLVIII.—*Seasonal diameter growth of Parashorea malaanonan (bagtican lauan) in the open at the base of Mount Maquiling; altitude, about 100 meters*—Continued.

Diameter.	Jan. 29 to Mar. 26.	Mar. 26 to Apr. 29.	Apr. 29 to June 2.	June 2 to July 24.	July 24 to Oct. 13.	Oct. 13 to Dec. 10.	Dec. 10 to Jan. 29.
cm.							
4.35	0.025	0.000	0.057	0.054	0.086	0.067	0.069
4.70	0.041	0.029	0.070	0.054	0.080	0.099	0.035
4.925	0.010	0.029	0.111	0.092	0.038	0.016	0.016
4.875	0.035	0.000	0.099	0.083	0.086	0.032	0.035
Average	0.023	0.012	0.079	0.077	0.083	0.055	0.049
7.105	0.016	0.029	0.099	0.083	0.127	0.165	0.069
7.605	0.010	0.013	0.013	0.092	----------	----------	0.025
6.15	0.000	0.041	0.057	0.054	0.073	0.073	0.051
5.15	0.016	0.000	0.000	0.102	0.143	0.067	0.095
6.04	0.000	0.000	0.041	0.127	0.089	0.000	0.051
5.39	0.000	0.041	0.000	0.073	0.137	0.057	0.061
6.95	0.000	0.000	0.086	0.054	0.048	0.010	0.061
6.105	0.000	0.041	0.029	0.038	0.057	0.016	0.035
5.15	0.000	0.013	0.070	0.054	0.073	0.057	0.025
5.06	0.016	0.013	0.029	0.111	0.150	0.032	0.085
7.35	0.010	0.000	0.041	0.083	0.105	0.099	0.069
7.37	0.016	0.057	0.070	0.156	0.064	0.172	0.105
6.16	0.000	0.000	0.057	0.045	0.102	0.099	0.051
5.425	0.041	0.000	0.041	0.029	0.073	0.000	0.051
6.00	0.016	0.000	0.057	0.054	0.041	0.041	0.061
6.405	0.010	0.013	0.041	0.064	0.095	0.073	0.061
5.04	0.000	0.013	0.086	0.064	0.054	0.000	0.105
6.695	0.025	0.000	0.041	0.092	0.095	0.099	0.069
5.75	0.035	0.013	0.070	0.064	0.080	0.083	0.051
5.51	0.035	0.029	0.099	0.045	0.086	0.067	0.025
5.02	0.102	0.029	0.181	0.102	0.127	0.073	0.051
6.63	0.067	0.000	0.013	0.184	0.105	0.067	0.051
5.90	0.086	0.029	0.127	0.102	0.127	0.114	0.082
9.00	0.000	0.000	0.029	0.038	0.064	0.051	0.016
9.2	0.092	0.029	0.156	0.146	0.137	0.073	0.061
7.97	0.086	0.000	0.127	0.102	0.073	0.057	0.061
9.3	0.051	0.029	0.111	0.102	0.073	0.073	0.025
Average	0.027	0.016	0.066	0.084	0.092	0.066	0.058
10.05	0.000	0.000	0.041	0.064	0.165	0.032	0.035
13.6	0.016	0.000	0.099	0.092	0.169	0.114	0.051
13.8	0.010	0.000	0.156	0.083	0.150	0.089	0.016
10.95	0.086	0.057	0.140	0.102	0.134	0.010	0.156
10.24	0.060	0.041	0.181	0.111	0.073	0.051	0.025
10.88	0.067	0.057	0.127	0.064	0.095	0.051	0.035
11.10	0.095	0.070	0.127	0.111	0.118	0.016	0.069
Average	0.048	0.032	0.124	0.089	0.129	0.052	0.055

28. An examination of this figure shows that the slowest growth was made during the dry season, and the most rapid, during the rainy period. An attempt was made to correlate the seasonal

rates with changes in climatic factors. It is very clear that the variations in rates of growth do not follow the variations in any single factor. Thus, temperature and light intensity are high when growth is slowest, while growth is also slow when tem-

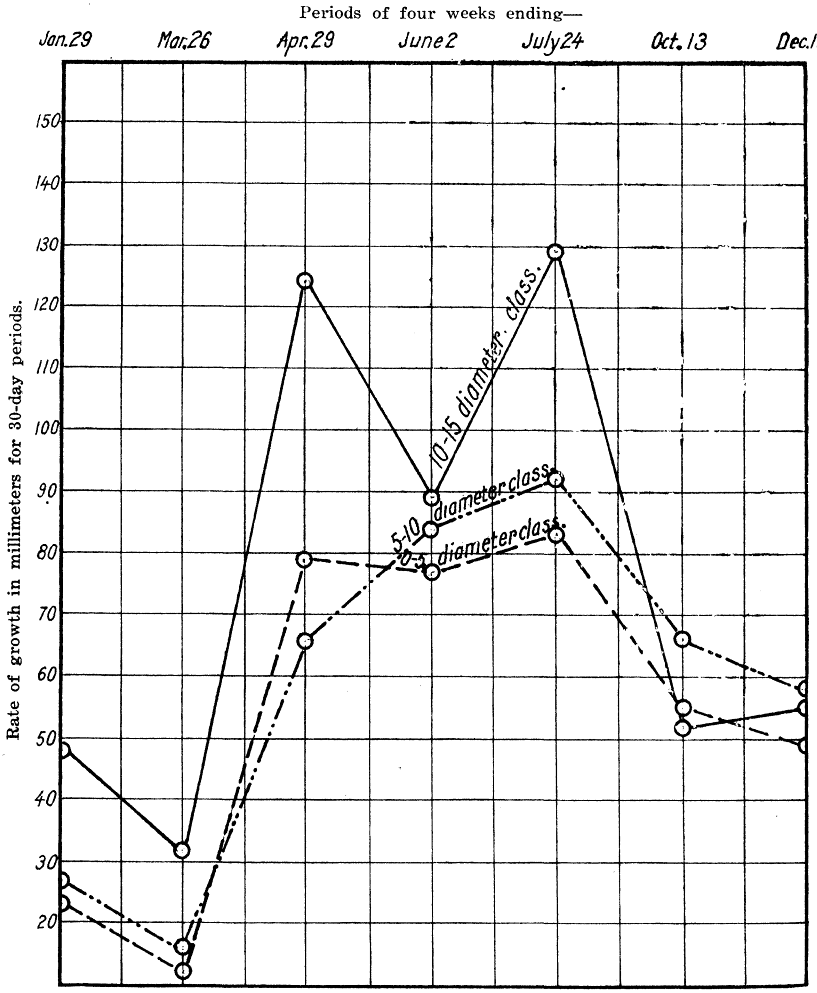

FIG. 28. Seasonal diameter growth of *Parashorea malaanonan* (bagtican lauan) in the open at the base of Mount Maquiling; altitude, about 100 meters.

perature and light intensity are lowest. When evaporation is greatest the rates of growth are slowest; but, at the end of the year, when the rate of evaporation is lowest and the moisture content of the soil high, there is also a period of slow growth. Moreover, no combination of different factors has been found which varied in the same manner as do the rates of growth.

This may be due in part to growth not being coincident with the elaboration of food materials, and to the fact that we have no means of estimating the relation of evaporation and soil moisture to the rates of growth. In the introductory paragraphs in the discussion of growth it was pointed out that high transpiration during the day is accompanied by a decrease in the diameter of the tree trunks, these returning to their original size at night. It was also mentioned that Petch * had found that trees of *Hevea brasiliensis* might shrink as much as 3 millimeters during the dry season. It is not at all improbable that, in taking seasonal measurements, variations in diameter due to swelling and shrinking may play a considerable rôle in causing the changes observed, and this may also account in part for the lack of agreement between rates of growth and seasonal changes of environment.

Despite these facts there seems to be a general sort of relation between environment and rates of growth. At the height of the dry season, when the soil moisture is lowest and the evaporation highest, the adverse effect of dry conditions upon the trees is shown in loss of foliage and in the slowest rate of growth for the entire year being made at that time. With the advent of heavier rains growth becomes more rapid, and it is during the rainy season that the most rapid growth takes place. Following this there is a period at the end of the year when, although the rate of evaporation is low and the moisture content of the soil high, there is a slow rate of growth. At this time, however, the light intensity and temperature both reach a minimum, which may account for this slow rate of growth. After January the light intensity and temperature increase rapidly, but by this time the dry season has set in, and the rate of evaporation reaches a maximum during the time that light intensity and temperature would appear to be most favorable. The high rate of evaporation and the lower moisture content of the soil at this time apparently more than offset the favorable temperature and light intensity.

Measurements of seasonal rates of growth were also made on one hundred twenty-one individuals of second-growth trees. A summary of the results is given in Table CXLIX and is plotted in fig. 29. This curve, while not agreeing in detail with the curves for *Parashorea*, shows the same general form. The chief difference is that the rate of growth of the second-growth

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* Petch, T., The girth increment of Hevea brasiliensis, *Ann. Roy. Bot. Gardens, Peradeniya* (1916), 6, 1–10.

TABLE CXLIX.—*Average seasonal diameter growth of 121 second-growth trees near the base of Mount Maquiling; altitude, about 80 meters. All figures are reduced to rates in centimeters for 30 days.*

Period.	Rate of growth.
January 15 to February 16	0.200
February 16 to March 24	0.178
March 24 to April 28	0.155
April 28 to June 18	0.183
June 18 to July 24	0.252
July 24 to October 8	0.252
October 8 to December 1	0.197
December 1 to January 15	0.162

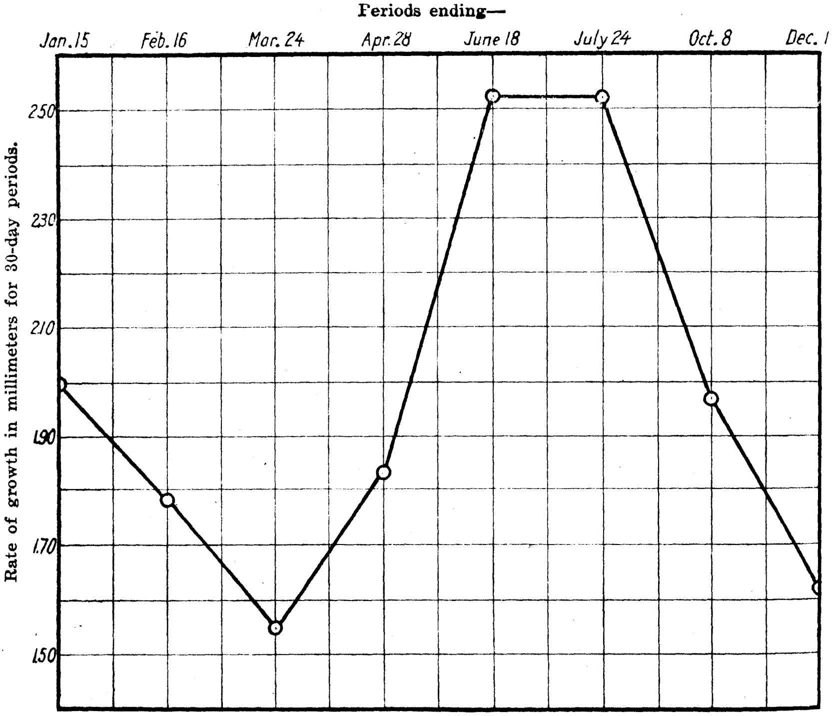

FIG. 29. Average seasonal diameter growth of 121 second-growth trees near the base of Mount Maquiling; altitude, 80 meters.

trees from April 28 to June 28 was slow, whereas *Parashorea* made a rapid growth between April 29 and June 2. Like *Parashorea* the second-growth trees showed the slowest rate of growth during the dry season and the most rapid rate during the rainy period; and an intermediate rate at the end of the year, when moisture conditions would appear to have been favorable, but when light intensity and temperature were lowest.

SEASONAL GROWTH IN THE DIPTEROCARP FOREST

Seasonal rates of growth of *Parashorea malaanonan* in the virgin forest at an altitude of about 300 meters were measured by Brown and Matthews.* The results are presented in detail in their publication and are plotted in their fig. 12. This figure is here reproduced as fig. 30. The curves in fig. 30 also show the slowest rate of growth at the height of the dry season, the

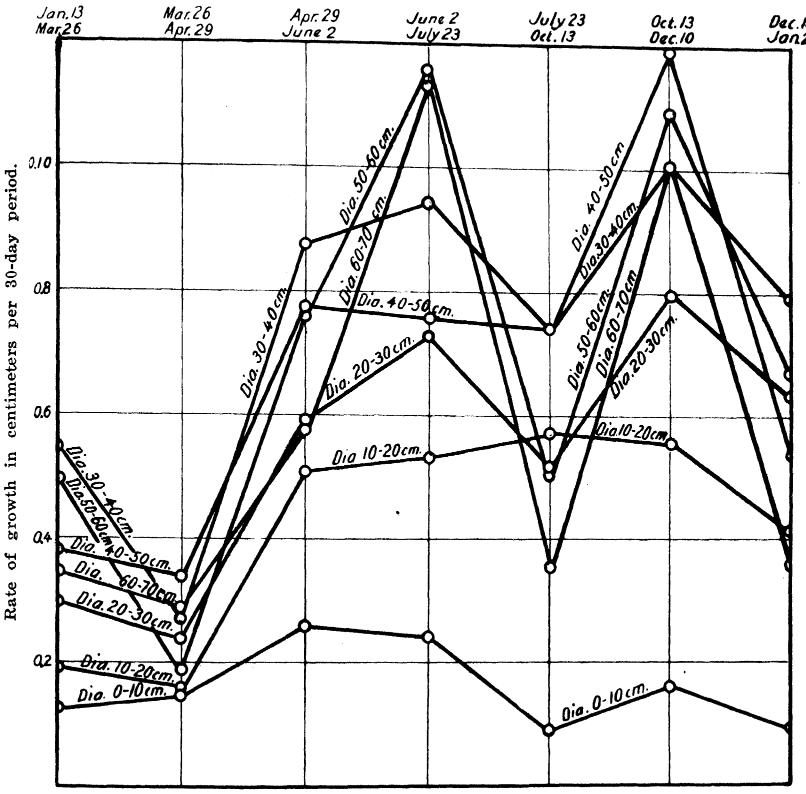

FIG. 30. Seasonal rates of diameter growth of *Parashorea malaanonan* in dipterocarp forest; altitude, about 300 meters.

most rapid growth during the rainy period, and an intermediate rate at the end of the year. There are, however, some striking differences between these curves for the virgin forest and those for the trees near the base of the mountain. The period from the first part of October to the first of December was one during which the trees at 80 meters' elevation showed a slow rate of

* Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests. *Phil. Journ. Sci., Sec. A* (1914), 9, 451.

growth, but during which *Parashorea* in the forest made a very rapid growth. The period from the last of July to the first part of October was one of rapid growth at an elevation of 80 meters and of slow growth for *Parashorea* in the virgin forest. During this period the light intensity in the virgin forest was less than during either the preceding or the following period; and it may be that with the diminished light at this altitude the great amount of cloudiness during the rainy season was responsible for this slow rate in the virgin forest. It is interesting to note that the rate at this time is not very different from that at the end of the year, and that the light intensity, as measured by the difference in evaporation from the white and the radio-atmometers, was similar during the two periods. The changes in rate of growth in the virgin forest would seem to be best explained by assuming that the slow rate of growth during the dry season was due to high evaporation rates and low moisture content of the soil, and that as moisture conditions became more favorable the rate of growth increased. However, when moisture conditions during the rainy season were still very favorable the low light intensity was apparently responsible for a decreased rate of growth. As the light intensity again increased the rate of growth increased, while at the end of the year, when both light intensity and temperature were low, the rate of growth again decreased.

A consideration of the rates of seasonal growth in the parang and in the lower portion of the dipterocarp forest would indicate that the rates of growth are influenced by changes in light intensity, temperature, and evaporation. This is what might be expected from the discussion previously given under the heading of Light, where it was shown that variations in temperature and light appeared to be sufficient to account for the changes in height from the tall forest at lower elevations to the dwarfed one at higher altitudes. In the same discussion it was pointed out that the trees in the lower part of the dipterocarp forest were not so tall as would be indicated by the temperature-light indices, and it was suggested that this difference might be due to high rates of evaporation, particularly during the dry season.

Variations in light apparently show a greater effect on seasonal rates of growth of trees in the virgin forest than upon those at an elevation of 80 meters, where growth appears to be more largely controlled by moisture conditions. This again is in harmony with the view previously expressed that trees that formerly existed in the latter area were probably not nearly so

tall as would be indicated by the temperature-light indices, while those growing in a virgin forest in regions with a more evenly distributed rainfall do reach the heights indicated by the temperature-light indices for the base of Mount Maquiling.

As the high rates of evaporation obtaining during the dry season in the lower part of the dipterocarp forest and in the parang appear to have such adverse effects on the rates of growth, it seems probable that the lower rates of evaporation occurring at higher elevations should be favorable, rather than detrimental, to the development of a tall forest. This consideration suggests that it is the low light intensity and temperature, rather than the low rates of evaporation, that are responsible for the dwarfing of the trees at higher elevations. This idea is in harmony with the view previously expressed in the discussion on Evaporation.

CLASSIFICATION OF LEAVES

CLASSIFICATION ACCORDING TO RAUNKIAER'S LEAF SIZES

A system of classifying the leaves in different plant habitats has been devised by Raunkiaer.* An abbreviated translation of this work has been presented by Fuller and Bakke.† According to Raunkiaer's system, leaves smaller than 25 square millimeters are leptophylls; those from 25 to 225 square millimeters, nanophylls; 225 to 2,025, microphylls; 2,025 to 18,225, mesophylls;

TABLE CL.—*Classification of erect woody plants on Mount Maquiling according to Raunkiaer's leaf sizes. (Ferns and palms are omitted.)*

PLANTS OVER 2 METERS IN HEIGHT ON 0.25 HECTARE IN VIRGIN DIPTEROCARP FOREST; ALTITUDE, 450 METERS.

	Species.			Individuals.		
	Microphyll.	Mesophyll.	Macrophyll.	Microphyll.	Mesophyll.	Macrophyll.
First-story species	1	21		1	86	
Second-story species	3	34	5	6	140	22
Third-story species		20	4		63	16
Undergrowth species		4			6	
Total	4	79	9	7	295	38
PLANTS OVER 1 METER IN HEIGHT ON 0.25 HECTARE IN MIDMOUNTAIN FOREST (QUERCUS-NEOLITSEA ASSOCIATION); ALTITUDE, 700 METERS.						
First-story species	2	32	1	10	117	1
Second-story species	2	28	4	5	412	17
Shrubs		1			1	
Total	4	61	5	15	530	18
PLANTS MORE THAN 1 METER IN HEIGHT ON 0.05 HECTARE IN MOSSY FOREST; ALTITUDE, 1,000 METERS.						
First-story species	8	8		57	56	

* Raunkiaer, C., Om Bladstorrelsens Anvendelse i den biologiske Plantegeografi, *Bot. Tidsk.* (1916), **33**, 225–240.

† Fuller, G. D., and Bakke, A. L., Raunkiaer's "Life Forms," "Leaf-Size Classes," and statistical methods, *Plant World* (1918), **21**, 25.

18,225 to 164,025, macrophylls; while larger leaves are megaphylls. In Table CL the erect woody dicotyledonous plants on the plots previously described, at different altitudes on Mount Maquiling, are classified according to Raunkiaer's system, both by number of individuals and by number of species. In this table the sizes given for compound leaves refer to the leaflets.

An examination of the table shows that only three of Raunkiaer's leaf sizes were represented on these plots in the virgin forests; these were microphylls, mesophylls, and macrophylls. In the dipterocarp and midmountain forests the leaves were predominantly mesophylls, although in both cases there were some species with microphylls and some with macrophylls. In the mossy forest there were only two leaf sizes, microphylls and mesophylls. These were represented by the same number of species, while there was one more individual with microphylls than with mesophylls. This shows at once that the leaves in the mossy forest were smaller than those at lower elevations. In the midmountain forest there was, moreover, a smaller percentage of macrophylls and a slightly larger percentage of microphylls than in the dipterocarp forest, which might indicate that the leaves in the midmountain forest are smaller than in the dipterocarp forest. However, since such a large proportion of the leaves were mesophylls, it would appear that this class covers too large a range to allow an accurate comparison to be made of the sizes of leaves in the midmountain and dipterocarp forests.

CLASSIFICATION ACCORDING TO LENGTH AND BREADTH

In order to compare the leaf sizes at different altitudes more closely and also to see whether changes in length and breadth are proportional at different altitudes, the leaves have been classified according to length and breadth in a series of tables. These tables are similar in form. The leaves are classified according to length classes of 10 centimeters and width classes of 5 centimeters. The measurements of simple and compound leaves are presented separately. The sizes of the compound leaves are for the whole leaves and not for the leaflets as in Table CL. The species and individuals are also classified according to the character of the margins. Such data for the erect woody dicotyledonous plants in the culled dipterocarp forest are given in Table CLI; for those in the virgin dipterocarp forest, in Table CLII; for those in the midmountain forest, in Table

TABLE CLI.—*Leaf characters of trees over 1 meter in height on 0.25 hectare in the culled dipterocarp forest on Mount Maquiling; altitude, 200 meters.*[a]

SIMPLE LEAVES.

	Length in centimeters.						Width in centimeters.							
	0 to 10.		10 to 20.		20 to 30.		0 to 5.		5 to 10.		10 to 15.		15 to 20.	
	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.
First-story species:														
Dipterocarps			3	81					3	81				
Miscellaneous	4	9	12	240	1	2	7	14	9	235			1	2
Second-story species	6	19	46	268	5	51	16	43	30	173	7	76	4	46
Third-story species	3	5	17	61	1	3	7	12	12	51	2	6		
Undergrowth species			2	13			2	13						
Total	13	33	80	663	7	56	32	82	54	540	9	82	5	48

COMPOUND LEAVES.

	0 to 10. Species.	0 to 10. Individuals.	10 to 20. Species.	10 to 20. Individuals.	20 to 30. Species.	20 to 30. Individuals.	0 to 5. Species.	0 to 5. Individuals.	5 to 10. Species.	5 to 10. Individuals.	10 to 15. Species.	10 to 15. Individuals.	15 to 20. Species.	15 to 20. Individuals.
First-story species:														
Dipterocarps														
Miscellaneous			2	4	4	6	1	2	1	1	1	2	3	5
Second-story species			8	31	4	57					8	43	4	45
Third-story species	1	3	2	8	4	16	1	3					6	24
Undergrowth species														
Total	1	3	12	43	12	79	2	5	1	1	9	45	13	74

CHARACTER OF MARGIN OF ALL LEAVES.

	Entire.		Not entire.	
	Species.	Individuals.	Species.	Individuals.
First-story species:				
Dipterocarps	3	81		
Miscellaneous	20	256	3	5
Second-story species	58	409	11	17
Third-story species	20	66	8	30
Undergrowth species	2	13		
Total	103	825	22	52

[a] Five undetermined individuals and 5 palms are not included in this table.

TABLE CLII.—*Leaf characters of erect, woody plants over 2 meters in height on 0.25 hectare in the virgin dipterocarp forest on Mount Maquiling; altitude, 450 meters.*[a]

SIMPLE LEAVES.

	Length in centimeters.						Width in centimeters.							
	0 to 10.		10 to 20.		20 to 30.		0 to 5.		5 to 10.		10 to 15.		15 to 20.	
	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.
First-story species:														
Dipterocarps	1	1	2	33			1	1	2	33				
Miscellaneous	2	5	9	25	1	4	4	18	7	12	1	4		
Second-story species	7	14	19	80	8	37	10	28	18	75	4	26	2	2
Third-story species	2	3	14	38	4	18	6	7	10	35	2	2	2	15
Undergrowth species	1	1	3	5			2	4	2	2				
Total	13	24	47	181	13	59	23	58	39	157	7	32	4	17

COMPOUND LEAVES.

First-story species:														
Dipterocarps														
Miscellaneous			3	6	4	13			2	5	2	5	3	9
Second-story species			5	27	2	9					4	23	3	13
Third-story species					3	20							3	20
Undergrowth species														
Total			8	33	9	42			2	5	6	28	9	42

CHARACTER OF MARGIN OF ALL LEAVES.

	Entire.		Not entire.	
	Species.	Individuals.	Species.	Individuals.
First-story species:				
Dipterocarps	3	34		
Miscellaneous	15	45	4	8
Second-story species	34	137	7	30
Third-story species	14	50	9	29
Undergrowth species	2	4	2	2
Total	68	270	22	69

[a] *Livistona* sp., a palm represented by 13 plants, and 1 undetermined individual, are not included in this table.

TABLE CLIII.—*Leaf characters of trees over 1 meter in height on 0.25 hectare in the midmountain forest (Quercus-Neolitsea association) on Mount Maquiling; altitude, 700 meters.*[a]

SIMPLE LEAVES.

	Length in centimeters.						Width in centimeters.							
	0 to 10.		10 to 20.		20 to 30+.		0 to 5.		5 to 10.		10 to 15.		15+.	
	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.
First-story species	8	30	20	86	1	1	9	54	18	59	2	4		
Second-story species	2	4	23	372	3	9	14	199	9	168	2	6	3	12
Total	10	34	43	458	4	10	23	253	27	227	4	10	3	12
COMPOUND LEAVES.														
First-story species			3	6	3	5			1	2	1	3	4	6
Second-story species					5	48			1	2			4	46
Total			3	6	8	53			2	4	1	3	8	52

CHARACTER OF MARGIN OF ALL LEAVES.

	Entire.		Not entire.	
	Species.	Individuals.	Species.	Individuals.
First-story species	27	107	8	21
Second-story species	22	311	11	122
Total	49	418	19	143

[a] *Cyathea caudata*, a tree fern; *Pinanga*, a palm; and 1 undetermined specimen are not included in this table.

TABLE CLIV.—*Leaf characters of erect, woody plants more than 1 meter in height on 0.05 hectare in the mossy forest on Mount Maquiling; altitude 1,100 meters.*[a]

SIMPLE LEAVES.

Length in centimeters.						Width in centimeters.							
0 to 10.		10 to 20.		20 to 30.		0 to 5.		5 to 10.		10 to 15.		15 to 20.	
Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.
11	79	5	34			12	85	4	28				

TABLE CLIV.—*Leaf characters of erect, woody plants more than 1 meter in height on 0.05 hectare in the mossy forest on Mount Maquiling; altitude 1,100 meters*—Continued.

CHARACTER OF MARGIN OF ALL LEAVES.

Entire.		Not entire.	
Species.	Individuals.	Species.	Individuals.
11	88	5	25

[a] *Cyathea caudata*, a tree fern, represented by 44 individuals, is not included in this table.

TABLE CLV.—*Leaf characters of plants less than 1 meter in height on plot 10 meters square in culled dipterocarp forest on Mount Maquiling; altitude 200 meters.*

SIMPLE LEAVES.

	Length in centimeters.						Width in centimeters.							
	0 to 10.		10 to 20.		20 to 30 +.		0 to 5.		5 to 10.		10 to 15.		15 to 20 +.	
	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.
Trees	3	13	11	28	----	----	5	7	9	34	----	----	----	----
Herbs	----	----	2	35	1	11	1	11	2	35	----	----	----	----
Vines	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Total	3	13	13	63	1	11	6	18	11	69	----	----	----	----
COMPOUND LEAVES.														
Trees	----	----	2	2	3	18	----	----	----	----	2	2	3	18
Herbs	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Vines	----	----	----	----	2	4	----	----	----	----	----	----	2	4
Total	----	----	2	2	5	22	----	----	----	----	2	2	5	22

CHARACTER OF MARGIN OF ALL LEAVES.

	Entire.		Not entire.	
	Species.	Individuals.	Species.	Individuals.
Trees [a]	17	59	2	2
Herbs	2	23	1	23
Vines	----	----	2	4
Total	19	82	5	29

[a] One undetermined individual is not included.

TABLE CLVI.—*Leaf characters of plants on a plot 10 meters square in the dipterocarp forest on Mount Maquiling; altitude, 450 meters.*

	Length in centimeters.						Width in centimeters.							
	0 to 10.		10 to 20.		20 +.		0 to 5.		5 to 10.		10 to 15.		15 +.	
	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.
SIMPLE LEAVES.														
Trees [a]	5	14	16	91	7	13	8	17	17	94	1	2	2	5
Shrubs			1	1			1	1						
Herbs	2	21	2	32	2	11	3	22	2	32	1	10		
Vines [b]	1	1	3	9	2	4	3	6	2	7			1	1
Total	8	36	22	133	11	28	15	46	21	133	2	12	3	6
COMPOUND LEAVES.														
Trees [a]			2	13	5	12					3	14	4	11
Shrubs														
Herbs					2	2							2	2
Vines [b]			1	53	2	82					1	53	2	82
Total			3	66	9	96					4	67	8	95

CHARACTER OF MARGIN OF ALL LEAVES.

	Entire.		Not entire.	
	Species.	Individuals.	Species.	Individuals.
Trees [a]	27	118	8	25
Shrubs	1	1		
Herbs	5	45	3	21
Vines [b]	6	63	3	86
Total	39	227	14	132

[a] Undetermined individuals and palms are not included.
[b] Undetermined individuals are not included.

CLIII; and for those in the mossy forest, in Table CLIV. Similar data for the plots 10 meters square, on which all plants were measured, are given in Tables CLV to CLVII. In order to present these figures in a more convenient form they have been converted into percentages and set forth in Tables CLVIII to CLXIII.

Table CLVIII gives the percentages of simple-leaved plants with leaves less than 5 centimeters in width. This table shows very clearly that the number of plants with leaves less than 5

TABLE CLVII.—*Leaf characters of plants on a plot 10 meters square in the midmountain-forest formation on Mount Maquiling; altitude, 700 meters.*

SIMPLE LEAVES.

	Length in centimeters.						Width in centimeters.							
	0 to 10.		10 to 20.		20 to 30 +.		0 to 5.		5 to 10.		10 to 15.		15 to 20.	
	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.	Species.	Individuals.
Trees	6	46	12	42	----	----	11	74	7	14	----	----	----	----
Herbs	2	814	3	517	2	12	4	1,288	3	55	----	----	----	----
Vines	1	1	2	38	1	5	2	31	2	13	----	----	----	----
Total	9	861	17	597	3	17	17	1,393	12	82	----	----	----	----
COMPOUND LEAVES.														
Trees	----	----	2	2	3	32	----	----	1	1	1	1	3	32
Herbs	----	----	1	2	----	----	----	----	1	2	----	----	----	----
Vines	----	----	----	----	3	119	----	----	----	----	----	----	3	119
Total	----	----	3	4	6	151	----	----	2	3	1	1	6	151

CHARACTER OF MARGIN OF ALL LEAVES.

	Entire.		Not entire.	
	Species.	Individuals.	Species.	Individuals.
Trees	18	111	5	11
Herbs	5	137	3	1,208
Vines	3	29	4	134
Total	26	277	12	1,353

centimeters in width increases rapidly with rising elevations. This change is marked in the first- and second-story trees and in the herbs. In Table CLIX are presented the percentages of simple-leaved plants with leaves less than 10 centimeters in length. The data in this table agree in general with the data in Table CLVIII in showing that the number of plants with small leaves is greater at higher than at lower elevations.

In Table CLX are given the percentages of simple-leaved plants with leaves more than 10 centimeters in width. An examination of this table shows that the number of both species and individuals with such leaves is greater in the dipterocarp than in the midmountain forest, while not one is found in the mossy forest. Table CLXI gives the percentages of simple-leaved plants with leaves more than 20 centimeters in length. The virgin dipter-

TABLE CLVIII.—*Percentages of simple-leaved plants on Mount Maquiling with leaves less than 5 centimeters in width.*

BY INDIVIDUALS.

	First-story species.	Second-story species.	Third-story species.	Herbs.	All erect woody plants more than 1 or 2 meters in height.
Culled dipterocarp forest	4	13	17	24	11
Virgin dipterocarp forest	28	21	12	34	22
Midmountain forest	46	52	----------	96	50
Mossy forest	75	----------	----------	----------	75
BY SPECIES.					
Culled dipterocarp forest	35	28	33	33	32
Virgin dipterocarp forest	33	29	30	50	32
Midmountain forest	31	50	----------	57	40
Mossy forest	75	----------	----------	----------	75

TABLE CLIX.—*Percentages of simple-leaved plants on Mount Maquiling with leaves less than 10 centimeters in length.*

BY INDIVIDUALS.

	First-story species.	Second-story species.	Third-story species.	Herbs.	All erect woody plants more than 1 or 2 meters in height.
Culled dipterocarp forest	3	6	7	0	4
Virgin dipterocarp forest	9	11	5	33	9
Midmountain forest	26	1	----------	66	7
Mossy forest	70	----------	----------	----------	70
BY SPECIES.					
Culled dipterocarp forest	20	11	14	0	13
Virgin dipterocarp forest	20	21	10	33	18
Midmountain forest	28	7	----------	29	18
Mossy forest	69	----------	----------	----------	69

ocarp forest shows distinctly larger percentages of these long leaves than does the midmountain forest, while not one is present in the mossy forest.

From the data in the four tables just discussed it would seem clear that the percentage of large leaves decreases while the percentage of small ones increases with rising elevations. The explanation of this is not obvious. It can hardly be due to moisture

TABLE CLX.—*Percentages of simple-leaved plants on Mount Maquiling with leaves more than 10 centimeters in width.*

	First-story species.	Second-story species.	Third-story species.	Herbs.	All erect woody plants more than 1 or 2 meters in height.
BY INDIVIDUALS.					
Culled dipterocarp forest	0.6	36	9	0	17
Virgin dipterocarp forest	6	21	29	16	19
Midmountain forest	3	5		0	4
Mossy forest	0				0
BY SPECIES.					
Culled dipterocarp forest	5	19	10	0	14
Virgin dipterocarp forest	7	18	20	17	15
Midmountain forest	7	18		0	12
Mossy forest	0				0

TABLE CLXI.—*Percentages of simple-leaved plants on Mount Maquiling with leaves more than 20 centimeters in length.*

	First-story species.	Second-story species.	Third-story species.	Herbs.	All erect woody plants more than 1 or 2 meters in height.
BY INDIVIDUALS.					
Culled dipterocarp forest	0.6	15	4	24	7
Virgin dipterocarp forest	6	28	31	17	22
Midmountain forest	0.9	2		0.9	2
Mossy forest	0				0
BY SPECIES.					
Culled dipterocarp forest	5	9	5	33	7
Virgin dipterocarp forest	7	24	20	33	18
Midmountain forest	3	11		29	7
Mossy forest	0				0

conditions, as the rate of evaporation decreases and the percentage of soil moisture rises with increasing altitudes. Moreover, there is a greater proportion of large leaves in the parang than at higher elevations, while in the parang the rate of evaporation is higher and the percentage of soil moisture lower than anywhere in the virgin forest. Wind may afford a partial explanation, as wind velocity is greater at high than at low altitudes, and a tree

with large leaves would probably be more likely to be defoliated by high wind velocities than would one with small leaves. It may be, however, that the small size of leaves at high elevations is simply an expression of the poor conditions for growth that result in the conspicuous dwarfing of trees. Raunkiaer in his studies found the smallest leaves on the area with the lowest vegetation. In the second-growth forest at the base of Mount Maquiling the trees are of small size, but this is not due to poor growth conditions. As just mentioned, these trees have a greater percentage of large leaves than those in the virgin forest.

The second-story trees in the dipterocarp and midmountain forests do not appear to have smaller leaves than the first-story trees. From Table CLVIII, in which are given the percentages of simple-leaved plants with leaves less than 5 centimeters in width, it will be seen that a smaller percentage of such leaves is found in the second than in the first story of the dipterocarp forest, while the percentage is only slightly greater in the second story than in the first story of the midmountain forest. The percentage of plants with leaves less than 10 centimeters in length is much less in the second story of the midmountain forest than in the first, and only slightly greater in the second story of the virgin dipterocarp forest than in the first story. While the percentage of small leaves appears to be about the same in the first and second stories, the number of large leaves is considerably greater in the lower stories than in the first, as an examination of Tables CLX and CLXI will show. The occurrence of this high percentage of large leaves in the understories may be connected with lessened wind movement or lower evaporation. It will be noticed that the number of plants with leaves more than 10 centimeters in width and with leaves more than 20 centimeters in length is greater in the third story than in the second of the dipterocarp forest, and considerably greater in either of these stories than in the second story of the midmountain forest. The smaller percentage in the midmountain forest can hardly be due to rates of evaporation.

CLASSIFICATION ACCORDING TO WHETHER SIMPLE OR COMPOUND

In Table CLXII are given the percentages of plants with compound leaves. The number of individuals with compound leaves is less in the culled dipterocarp forest than in the virgin dipterocarp forest. The number of both species and individuals with compound leaves is much less in the midmountain than in the virgin dipterocarp forest, while there are no individuals with

TABLE CLXII.—*Percentages of plants on Mount Maquiling with compound leaves.*

BY INDIVIDUALS.

	First-story species.	Second-story species.	Third-story species.	Herbs.	All erect woody plants more than 1 or 2 meters in height.
Culled dipterocarp forest	3	21	28	0	14
Virgin dipterocarp forest	22	22	25	3	22
Midmountain forest	9	11		0.1	11
Mossy forest	0			0	0

BY SPECIES.

	First-story species.	Second-story species.	Third-story species.	Herbs.	All erect woody plants more than 1 or 2 meters in height.
Culled dipterocarp forest	23	17	25	0	20
Virgin dipterocarp forest	32	17	13	25	19
Midmountain forest	17	15		13	16
Mossy forest	0			0	0

TABLE CLXIII.—*Percentages of plants on Mount Maquiling which have leaves with entire margins.*

BY INDIVIDUALS.

	First-story species.	Second-story species.	Third-story species.	Herbs.	All erect woody plants more than 1 or 2 meters in height.
Culled dipterocarp forest	99	96	69	50	94
Virgin dipterocarp forest	91	82	63	68	80
Midmountain forest	84	72		10	75
Mossy forest	78				78

BY SPECIES.

	First-story species.	Second-story species.	Third-story species.	Herbs.	All erect woody plants more than 1 or 2 meters in height.
Culled dipterocarp forest	88	84	71	67	82
Virgin dipterocarp forest	82	83	61	63	76
Midmountain forest	77	67		63	72
Mossy forest	69				69

compound leaves in the mossy forest. In the virgin dipterocarp and the midmountain forests the percentage of individuals with compound leaves is approximately the same in the different stories. In the virgin dipterocarp forest the number of species with compound leaves is greatest in the first story and least in the third.

CLASSIFICATION ACCORDING TO CHARACTER OF MARGINS

The percentage of leaves with entire margins is given in Table CLXIII. It will be seen that the percentage of both individuals and species decreases with rising elevations and that in general the percentage of entire margins is smaller in the understories than in the first story. The lowest percentage in any of the tree stories in the dipterocarp forest is in the third story. The number of individuals, not only of woody species but also of herbs with entire margins, is less in the midmountain forest than in the virgin dipterocarp forest.

The changes in leaf margins at different elevations may perhaps be connected with moisture conditions, as the smallest percentage with entire margins is found in the mossy forest where fogs are of frequent occurrence and the rate of evaporation is low, and the greatest percentage in the dipterocarp forest where the rate of evaporation is very much higher. Water appears to run from leaves without entire margins more readily than from those with entire margins, and so nonentire margins may be of advantage to plants growing in places where the rate of evaporation is low. That the lower stories have a smaller percentage of entire margins than the first story is in keeping with this view.

Bailey and Sinnott * have made a study of the distribution of entire and nonentire margins as related to climatic conditions. This work was based on various floras. The following quotation from their summary is in general agreement with the results just given:

> Leaves and leaflets with entire margins are overwhelmingly predominant in lowland-tropical regions; those with non-entire margins in mesophytic cold-temperate areas.
>
> In the tropical zones, non-entire margins are favored by moist uplands, equable environments, and protected, comparatively cool habitats; in the cold-temperate zones, entire margins are favored by arid environments and other physiologically dry habitats.

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* Bailey, I. W., and Sinnott, E. W., The climatic distribution of certain types of angiosperm leaves, *Am. Journ. Bot.* (1916), 3, 24–39.

MOUNT BANAHAO

GENERAL DESCRIPTION

When the work on Mount Maquiling was finished, it seemed desirable to obtain some measurements of climatic factors on another mountain with a somewhat different type of vegetation, and to compare the results with those obtained on Mount Maquiling. Mount Banahao offered the best possibilities for such a study.

Mount Banahao is one of three extinct volcanic cones, which form an isolated mountain mass on the boundary between Laguna and Tayabas Provinces. It is the largest of the three and has an elevation of about 2,300 meters. The next in height is Mount Cristobal, which lies to the west of Mount Banahao and is connected with the latter by a narrow saddle. The other peak, Lukban Peak, is a small cone on the northeastern side of Mount Banahao. All three peaks are regular cones. Mount Banahao has a large crater which opens toward the south. The sides of the crater are very steep, while the rim is narrow and knifelike. The part of the mountain under discussion is on the northern slope, along the trail leading from Majayjay to the summit. On this side the mountain rises from the plains at U-uvi barrio at an elevation of about 450 meters.

The rainfall on the northern and northeastern slopes of Mount Banahao is distributed throughout all the months of the year, and there are no distinct wet and dry seasons.

The northeastern monsoon strikes the Islands on the eastern coast and deposits a large part of its moisture before passing over the mountain masses. As there are no high mountain masses northeast of Mount Banahao, this monsoon brings heavy rains to the northern and northeastern slopes of the mountain. The southwestern monsoon is not nearly so strong a wind as the northeastern monsoon and, although it brings rains on the western side of the Archipelago, a large part of the rains that come at this season of the year are the result of cyclonic disturbances (typhoons), which cause the deposition of rains on both sides of the Islands. Therefore, also during this monsoon, heavy rains occur on the northern slopes of Mount Banahao.

VEGETATION

Along the trail from Majayjay to the top of Mount Banahao the original forest vegetation has been almost entirely removed

to an elevation of about 650 meters, and even for some distance beyond this the forest has been culled of the trees most valuable for commercial purposes.

In describing the vegetation of Mount Banahao, it will be most convenient to give an account of the forest occurring at selected elevations.

At altitudes slightly above 650 meters the forest has been very badly culled. A number of the tallest trees were measured, and the greatest height was found to be about 17 meters. In this situation the diameters of the trees are rather large, compared with their heights. The greatest diameter recorded was 95 centimeters. The original forest was probably taller than that now found at this elevation. The development of epiphytes is rather scanty; the most frequent are *Aglaomorpha* and *Asplenium nidus*. On the trees are also found some mosses and a few orchids. The most conspicuous herbs on the ground are *Strobilanthes pluriformis, Elatostema longifolium,* and *Selaginella.* Climbing bamboos are conspicuous, and climbing palms (rattans) are rather numerous.

At 1,000 meters' elevation the tallest tree measured was 20 meters high, and the greatest diameter was 1.05 meters. The undergrowth here is very dense and consists largely of tree seedlings. The development of epiphytes is perhaps slightly greater than at lower elevations. *Piper longivaginans,* a liane, is abundant and conspicuous. Plate XL, fig. 1, shows a view in this forest.

The forest at an elevation of 1,500 meters is very open. The tallest trees are about 18 meters in height. Lianes are abundant and consist largely of species of *Freycinetia.* Owing to their abundance and the striking character of their foliage these form one of the most conspicuous elements in the vegetation. Among the most prominent trees are species of *Quercus.* Epiphytes are abundant but not enough so to influence materially the appearance of the vegetation. The most conspicuous epiphytes are orchids, the prominent species being *Bulbophyllum vagans, Dendrochilum pumilum,* and *Phreatea.*

The greatest development of epiphytes occurs at an elevation of about 1,800 meters. At this elevation there is a broad, shallow ravine which runs across the trail up the mountain. The trees are perhaps smaller in this ravine than at lower altitudes and are densely covered with thick layers of moss and mosslike plants. Plate XL, fig. 2, shows a view of this mossy forest. In exposed situations at this altitude the epiphytic covering is not particularly heavy.

The crater rim, at the point under discussion, has an elevation of approximately 2,100 meters. The forest is fairly open and consists of two stories of trees. The first, or dominant, story is composed almost entirely of *Podocarpus imbricatus*. Besides this species there are a few specimens of *Podocarpus costalis*. The tallest individuals of *Podocarpus imbricatus* reach heights of about 14 meters, while the average height of the main canopy is about 12 meters. Many of the trees have a tendency to lean downhill. The second story is composed of a few species of dicotyledonous trees, the most prominent of which is *Symplocos whitfordii*. Among the other prominent species are *Drimys piperita, Homalanthus alpinus, Clethra lancifolia, Rhododendron kochii, Symplocos luzoniensis,* and *Ilex crenata*. The undergrowth is scanty, giving the forest a fairly open appearance. The most important element in the undergrowth is a semiwoody herb, *Strobilanthes pluriformis*. The ground is largely bare. In places a small creping plant, *Nertera depressa*, forms conspicuous patches. Mosses, filmy ferns, and a few liverworts are scattered here and there. Epiphytic mosses and other epiphytes are rather scarce. The most prominent epiphyte is a small but showy orchid, *Dendrochilum venustulum*. Plate XXXIX shows two views in this forest.

From the foregoing discussion it will be seen that the vegetation on Mount Banahao differs strikingly from that on Mount Maquiling. At an elevation of 1,000 meters on Mount Banahao the tallest trees were 20 meters in height and the greatest diameter measured was 1.05 meters. At 1,500 meters the tallest trees were about 18 meters high. This is in striking contrast with the sizes of the trees at the top of the east peak of Mount Maquiling at an elevation of 1,050 meters, where the tallest trees were about 8 meters in height. Even at the top of Mount Banahao at an altitude of about 2,100 meters the tallest trees were about 14 meters in height, which is a much greater height than that of trees at the top of Maquiling. The dwarfing on Mount Banahao, while very perceptible, was therefore much less striking than on Mount Maquiling and much less in proportion to the altitude. At no elevation were epiphytes developed on ridges to a much greater extent than in the lower portion of the midmountain forest on Mount Maquiling.

There is a great difference between the species on Banahao and those on Maquiling, but perhaps the most striking floristic difference is the development, at the top of Mount Banahao, of a coniferous forest. A discussion of the rates of growth of

Podocarpus at the top of Mount Banahao has been presented previously.*

MEASUREMENTS OF ENVIRONMENTAL FACTORS

After completing the work on Mount Maquiling the writer became connected with the University of the Philippines in Manila and it was, therefore, impossible for him to live in the neighborhood of Mount Banahao and obtain a set of readings such as was obtained on Mount Maquiling. The trip from Manila to the top of Mount Banahao and back, without taking into consideration the time required for securing extensive measurements, cannot be made in much less than four days. These conditions made it necessary to have the readings taken by some one else, and this work was largely done by an assistant, Macario Ocampo, who had had no scientific training. It seemed inadvisable under the circumstances, to use atmometers, as a man without scientific training could hardly be expected to obtain accurate results with them. The only instruments employed were rain gauges, recording thermometers, and recording hygrometers. Owing to the simplicity of the rain gauge there seemed to be little chance of error in the use of this instrument, which opinion was borne out by the fact that the distribution of rainfall obtained at the various altitudes corresponds well with the distribution as recorded by the Weather Bureau stations near the coast in this region. With the slight changes in temperature found to obtain on Mount Banahao, there was practically no necessity for correcting the thermometers, and so the records of the temperature may be regarded as fairly accurate. The recording hygrometer presents greater difficulties, but even this instrument requires comparatively little correction under the fairly constant conditions obtaining on Mount Banahao. However, both the recording thermometers and the recording hygrometers were checked a number of times by the writer, and the slight corrections found necessary were made in the records. The results obtained from these several instruments are, therefore, probably about as accurate as could be expected from them.

The rain gauges were placed in the tops of trees, except at the two lower elevations, where they were on the ground in the open.

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* Brown, W. H., The rate of growth of Podocarpus imbricatus at the top of Mount Banahao, Luzon, Philippine Islands, *Phil. Journ. Sci., Sec. C* (1917), 12, 317–328.

At first instruments were installed only at an altitude of 1,550 meters and at the top of the mountain at an altitude of 2,100 meters. In these two situations the three types of instruments were operated from November 3, 1915, to November 3, 1916. Later rain gauges were installed at altitudes of 430, 660, and 1,015 meters. At an altitude of about 660 meters there are large clearings in the forest, and the rain gauge at this altitude was placed in such a clearing. The rain gauge at an altitude of 430 meters, which is considerably below the limits of the forest, was placed in an open field. Recording hygrometers and recording thermometers were also placed in the forest at elevations of 660 and 1,015 meters, and were operated from March, 1916, to November 1, 1916. The recording hygrometer at 1,015 meters did not run well during the latter part of the period, and so the records for this time have been omitted. The thermometers at the lower elevations were old and the clock works did not operate well, usually stopping before the end of the week, and sometimes running for only two or three days. The thermometer part of the instruments, however, worked accurately. Owing to the breaks in the records the maximum and minimum temperatures are not given in the tables for these elevations. The mean temperatures in both cases were calculated by adding together the average daily maximum and minimum and dividing by two.

TEMPERATURE

The temperature for the year in question at an altitude of 1,550 meters is summarized for four-week periods in Table CLXIV, and for the top of the mountain at an altitude of about 2,100 meters, in Table CLXV. The mean temperature at about 1,550 meters was 16.5°, which is 1.3° lower than at the top of Mount Maquiling. The mean temperature at the top of Mount Banahao was 14.6°, which is 3.2° lower than at the top of Mount Maquiling. Since the trees at an elevation of 1,550 meters and at the top of Mount Banahao are taller than at the top of Mount Maquiling, it would appear that temperature alone cannot explain the difference in the size of the trees on the two mountains. This is in agreement with the conclusion reached in the discussion of temperature on Mount Maquiling.

The average daily maximum temperature at 1,550 meters was 17.7°, and the average minimum, 15.4°, the average daily variation being 2.3°, which is less than the average variation at the top of Mount Maquiling, where it was 2.4°. As the average daily variation was less at the top of Mount Maquiling than at

TABLE CLXIV.—*Temperature for periods of four weeks in undergrowth in forest on Mount Banahao; altitude, about 1,550 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
1915.					
December 1	19.2	13.3	16.0	16.7	15.2
December 29	18.6	9.4	14.7	16.1	14.1
1916.					
January 26	18.3	9.9	14.9	15.8	13.8
February 23	19.2	11.2	15.1	16.2	14.3
March 22	18.3	12.0	15.2	16.8	14.2
April 19	20.6	12.8	16.1	17.4	14.9
May 17	20.8	14.9	17.6	18.5	16.6
June 14	20.8	15.5	17.8	19.1	16.6
July 12	21.9	15.0	17.7	19.1	16.3
August 9	20.8	15.3	17.5	19.1	16.1
September 6	21.1	13.9	17.5	18.8	16.2
October 4	20.5	13.6	16.8	17.9	15.6
November 1	21.9	13.9	18.0	19.0	16.9
Average			16.5	17.7	15.4

TABLE CLXV.—*Temperature for periods of four weeks in forest at the top of Mount Banahao; altitude, about 2,100 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
1915.					
December 1	17.7	10.6	14.9	15.9	13.3
December 29	17.1	10.0	13.8	14.7	13.1
1916.					
January 26	16.5	8.3	13.4	14.6	12.0
February 23	15.8	7.7	13.2	14.2	12.0
March 22	17.8	5.0	13.5	15.0	12.2
April 19	17.1	10.3	13.5	14.5	12.4
May 17	19.2	11.1	15.0	16.2	13.8
June 14	18.9	14.3	15.1	17.6	15.2
July 12	22.7	12.5	15.7	17.4	14.8
August 9	23.6	9.2	15.2	16.7	14.1
September 6	19.2	12.2	14.9	16.1	14.6
October 4	17.1	12.2	15.8	15.6	14.2
November 1	17.1	14.5	15.6	15.9	14.7
Average			14.6	15.7	13.6

the other elevations, it would appear that the average daily variation at 1,550 meters on Banahao is less than anywhere on Maquiling. The average daily maximum at the top of Mount

Banahao was 15.7°, and the average daily minimum, 13.6°, the average daily variation being 2.1°, which is slightly less than at 1,550 meters' elevation and probably less than at any elevation on Mount Maquiling.

The highest mean temperature for any four-week period at 1,550 meters was 18°, and the lowest, 14.7°, a difference of 3.3°. At the top of the mountain the highest mean for a four-week period was 15.8°, and the lowest, 13.2°, a difference of 2.6°. The absolute range for the entire year at 1,550 meters was 12.5°, and at the top, 18.6°. From these figures it will be seen that the temperature under the forest at high elevations on Mount Banahao is very uniform. The records for temperature at elevations of 660 and 1,015 meters are given in Tables CLXVI and CLXVII. The mean temperature at an eleva-

TABLE CLXVI.—*Temperature for periods of four weeks in forest on Mount Banahao; elevation, 660 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	Mean.	Average of daily—	
		Maxima.	Minima.
1916.			
April 19	20.5	20.9	20.1
May 17	22.6	23.6	21.5
June 14	21.1	22.9	19.2
July 12	20.5	22.3	18.6
September 6	20.6	21.8	19.3
October 4	20.8	22.2	19.3
Average	21.0	22.3	19.7

TABLE CLXVII.—*Temperature for periods of four weeks in forest on Mount Banahao; elevation, about 1,015 meters.*

[Numbers give degrees centigrade.]

Four weeks ending—	Mean.	Average of daily—	
		Maxima.	Minima.
1916.			
April 19	17.0	18.1	15.8
May 17	19.0	20.2	17.8
June 14	18.5	19.9	17.0
July 12	18.4	20.0	16.7
August 9	19.3	20.7	17.9
September 6	19.5	20.5	18.5
October 4	18.7	19.4	18.0
November 1	18.1	19.4	16.7
Average	18.6	19.8	17.3

tion of 1,015 meters from March, 1916, to November 1, 1916, was 18.6°. At 660 meters' elevation the mean temperature from March, 1916, to October, 1916, was 21°. At both of these altitudes the average daily range was slight, being 2.5° at 1,015 meters and 2.6° at 660 meters.

RAINFALL

The rainfall for weekly periods at different elevations is given in Table CLXVIII and is summarized for four-week periods in Table CLXIX. An examination of these tables will show that at elevations of 1,550 and 2,100 meters, the only stations

TABLE CLXVIII.—*Rainfall at different elevations on Mount Banahao.*

[Numbers give rainfall in centimeters.]

Week ending—	Approximate altitude in meters.				
	430.	660.	1,015.	1,550.	2,100.
1915.					
November 10				12.6	8.5
November 17				49.2	27.1
November 24				38.1	28.5
December 1				30.5	22.1
December 8				15.7	16.3
December 15				10.9	14.0
December 22				11.1	9.4
December 29				47.5	30.1
1916.					
January 5				27.5	18.3
January 12				13.2	9.2
January 19				29.1	14.5
January 26				24.2	47.6
February 2				30.3	59.8
February 9				0.65	0.23
February 16				14.6	10.5
February 23				8.5	15.2
March 1				7.1	6.5
March 8				13.8	9.5
March 15				4.15	3.15
March 22				2.12	2.65
March 29				1.65	15.7
April 5				8.4	0.52
April 12				21.1	13.6
April 19				13.3	10.5
April 26		45.6		29.3	19.8
May 3		10.5		8.16	10.1
May 10		9.8		10.1	7.15
May 17		13.1	31.9	12.6	27.0
May 24	1.62	7.05	4.3	5.05	17.1
May 31	3.82	9.9	6.5	5.09	5.01
June 7	3.16	20.9	22.8	9.6	14.3
June 14	7.12	1.73	8.1	7.01	13.0
June 21	2.13	11.2	10.1	13.8	6.01
June 28	2.88	0.00	1.75	3.41	9.6

TABLE CLXVIII.—*Rainfall at different elevations on Mount Banahao*—Ctd.

Week ending—	Approximate altitude in meters.				
	430.	660.	1,015.	1,550.	2,100.
1916.					
July 5	8.19	6.12	9.2	4.09	9.8
July 12	1.40	13.0	16.7	16.9	26.4
July 19	7.60	10.1	6.2	8.0	8.0
July 26	5.81	10.2	7.5	9.2	7.01
August 2	3.78	5.2	2.77	6.3	3.45
August 9	2.30	3.75	1.9	3.93	2.2
August 16	3.83	8.3	6.8	9.8	4.81
August 23	3.68	8.0	3.8	2.15	4.07
August 30	4.12	4.9	2.3	3.25	3.95
September 6	3.10	1.7	0.9	2.3	4.2
September 13	2.88	6.8	3.85	8.4	5.11
September 20	24.91	16.9	11.8	19.5	18.4
September 27	6.62	19.7	15.9	17.4	17.8
October 4	16.3	18.5	13.6	20.5	21.5
October 11	8.1	5.4	4.43	5.05	7.8
October 18	13.6	18.4	19.9	17.9	20.5
October 25	14.8	15.7	18.7	14.8	18.10
November 3[a]	12.5	25.1	32.3	25.1	41.2

[a] Nine days.

TABLE CLXIX.—*Rainfall for periods of four weeks at different elevations on Mount Banahao.*

[Numbers give rainfall in centimeters.]

Four weeks ending—	Approximate altitude in meters.				
	430.	660.	1,015.	1,550.	2,100.
1915.					
December 1				130.40	86.20
December 29				85.20	69.80
1916.					
January 26				94.00	89.60
February 23				54.05	85.73
March 22				27.17	21.80
April 19				44.45	40.32
May 17		79.00		60.16	64.05
June 14	15.72	39.58	41.70	26.75	49.41
July 12	14.60	30.32	37.75	38.20	51.81
August 9	19.49	29.25	18.37	27.43	20.66
September 6	14.73	22.90	13.80	17.50	17.03
October 4	50.71	61.90	45.15	65.80	62.81
November 3	49.00	64.60	75.33	62.85	87.60
Total, November 3, 1915, to November 3, 1916				733.96	746.82
Total, May 17, 1916, to November 3, 1916	164.25	248.55	232.10	238.53	289.32

for which there are continuous records for the year, the rainfall was heavy and was evenly distributed throughout the year. At the top of the mountain the total rainfall was 746.8 centimeters and there was no four-week period during which there was not more than 17 centimeters of rain. The total rainfall at 1,550 meters was 734 centimeters, and again there was no four-week period with less than 17 centimeters of rain. A comparison of the amounts of rain for similar periods at elevations from 660 to 2,100 meters would seem to indicate that there should be a very heavy rainfall at all altitudes in the virgin forest.

No measurements were made of the water content of the soil, but the soil always appeared moist, as would be expected from the heavy rainfall.

HUMIDITY

The relative humidity at an elevation of 1,550 meters is given in Table CLXX. The mean humidity for the entire year was 89.1; the average daily maximum, 92.6; and the average

TABLE CLXX.—*Relative humidity for periods of four weeks in undergrowth in the forest on Mount Banahao; altitude, about 1,550 meters.*

[Numbers give percentage of saturation.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1915.					
December 1	92.0	76.0	88.6	90.0	85.8
December 29	95.0	77.8	88.1	90.5	86.4
1916.					
January 26	92.0	31.0	87.8	90.1	82.9
February 23	99.5	57.0	84.6	94.4	84.1
March 22	99.0	39.3	91.9	96.3	81.4
April 19	99.0	59.0	89.5	93.6	82.8
May 17	99.0	71.5	89.7	93.1	82.8
June 14	98.0	70.0	90.9	94.3	85.8
July 12	97.0	83.0	91.7	94.3	87.3
August 9	95.0	72.0	89.5	92.2	83.9
September 6	97.5	68.3	89.5	92.8	84.2
October 4	97.0	72.5	88.8	92.9	83.9
November 1	95.8	76.0	87.3	89.3	83.6
Average			89.1	92.6	84.2

daily minimum, 84.2. There was no four-week period in which the average daily maximum was less than 89 per cent or the average daily minimum less than 81 per cent. During the entire year there was no period during which a maximum of 100 was registered by the instrument, and there was only one four-

week period during which the average daily maximum was more than 94.4. It would thus appear that absolute saturation must be relatively rare in this forest. The absolute minimum for the entire period was 31 per cent, showing that, although the average humidity is high, there may be periods of comparatively low humidity. The humidity for the top of the mountain is given in Table CLXXI. Here the average humidity was slightly higher

TABLE CLXXI.—*Relative humidity for periods of four weeks in the forest at the top of Mount Banahao; altitude, about 2,100 meters.*

[Numbers give percentage of saturation.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1915.					
December 1	93.0	81.5	89.8	91.1	88.4
December 29	97.5	85.0	90.1	91.7	88.3
1916.					
January 26	94.0	71.0	90.4	91.7	87.2
February 23	99.0	72.0	91.2	93.6	87.8
March 22	100.0	51.0	93.0	96.9	86.3
April 19	100.0	62.0	94.9	97.9	91.0
May 17	97.0	85.5	92.3	94.9	89.6
June 14	97.0	87.0	93.1	95.0	91.0
July 12	99.5	86.0	93.6	96.0	91.7
August 9	100.0	71.0	91.9	94.7	88.0
September 6	99.0	79.0	92.5	93.9	89.0
October 4	100.0	88.5	95.4	96.8	93.8
November 1	100.0	91.5	96.8	98.2	90.7
Average			92.7	94.8	89.4

than at 1,550 meters, being 92.7 per cent. The average daily maximum and average daily minimum were also higher, the former being 94.8, and the latter, 89.4 per cent. The lowest humidity recorded was 51 per cent, while 100 per cent was registered during five four-week periods. The relative humidity at an elevation of 1,015 meters is given in Table CLXXII, and at an elevation of 660 meters in Table CLXXIII.

In Table CLXXIV is given the mean relative humidity at the different altitudes from March, 1916, to November 1, 1916. From this table it would appear that there is comparatively little difference in the percentage of humidity at different elevations. The lowest average humidity occurred at 1,550 meters and the highest at the top, the difference being 4.2 per cent. No record of 100 per cent humidity is shown in Table CLXXIII for an

TABLE CLXXII.—*Relative humidity for periods of four weeks in undergrowth in the forest on Mount Banahao; altitude, about 1,015 meters.*

[Numbers give percentage of saturation.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1916.					
April 19	95.0	33.0	89.6	93.0	83.4
May 17	96.5	71.0	89.7	93.3	82.0
June 14	97.0	79.0	91.8	94.4	87.6
July 12	96.0	66.0	90.3	93.4	83.7
August 9	99.0	60.5	91.6	94.3	86.6
September 6	100.0	80.0	94.2	97.5	88.6
Average			91.2	94.3	85.3

TABLE CLXXIII.—*Relative humidity for periods of four weeks in the forest on Mount Banahao; altitude, about 660 meters.*

[Numbers give percentage of saturation.]

Four weeks ending—	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
1916.					
April 19	93.5	77.0	89.3	91.6	85.6
May 17	95.5	70.0	88.5	92.6	81.9
June 14	95.0	80.0	90.8	92.9	86.4
July 12	95.5	62.0	89.7	92.7	83.1
August 9	96.5	62.8	88.7	92.3	85.7
September 6	99.7	76.0	90.9	97.1	88.6
October 4	99.0	88.3	93.7	97.3	92.1
November 1	97.6	86.5	92.0	96.4	90.3
Average	99.7	62.0	90.4	94.1	86.7

TABLE CLXXIV.—*Mean humidity for periods of four weeks in undergrowth in the forest at different elevations on Mount Banahao.*

[Numbers give percentage of saturation.]

Four weeks ending—	Elevation in meters.			
	660.	1,015.	1,550.	2,100.
1916.				
April 19	89.3	89.6	89.5	94.9
May 17	88.5	89.7	89.7	92.3
June 14	90.8	91.8	90.9	93.1
July 12	89.7	90.3	91.7	93.6
August 9	88.7	91.6	89.5	91.9
September 6	90.9	94.2	89.5	92.5
October 4	93.7		88.8	95.4
November 1	92.0		87.3	96.8
Average	90.4	91.2	89.6	93.8

elevation of 660 meters, while 100 per cent was recorded for only one period at 1,015 meters.

CORRELATION OF ENVIRONMENT AND VEGETATION

An examination of the tables for relative humidity at different elevations would seem to afford an explanation of the fact that at no altitude is there a dense mossy covering in an exposed situation. The rarity with which a humidity of 100 per cent is recorded indicates that fogs which cause a condensation of water on the vegetation must be comparatively rare, as such fogs, if of long duration, would probably wet the hairs of the hygrometers and cause them to register complete saturation. The mean relative humidity at the three lower elevations is very similar to that in the midmountain forest on Mount Maquiling, while the mean relative humidity at the top of Mount Banahao is only 2.3 per cent higher than that in the midmountain forest at 740 meters on Mount Maquiling. At the top of Mount Maquiling the vegetation drips with moisture for a large part of the time. The writer has not observed such a condition on Mount Banahao except during or immediately following rains. At other times the leaves do not appear to be wet. We would, therefore, expect evaporation to be much more rapid at the different elevations on Mount Banahao than at the top of Mount Maquiling. The lack of fogs and the probably higher evaporation rates prevailing on Mount Banahao thus seem to explain the lack of a mossy forest in exposed situations there, even though the rainfall is much heavier than at any altitude on Mount Maquiling.

The comparative scarcity of complete saturation on Mount Banahao would indicate that cloudiness is not nearly so prevalent there as at the top of Mount Maquiling, so that the light intensity at all elevations is probably considerably greater than at the top of Maquiling. The similar relative humidity at elevations of 660, 1,015, and 1,550 meters may, moreover, indicate that the degree of cloudiness is much more uniform at these different elevations than on Mount Maquiling. This is in agreement with casual observations of the weather made by the writer on Mount Banahao. Owing to this and to the slighter degree of dwarfing with rising altitudes than obtains on Mount Maquiling, it would seem probable that the lower temperature at higher elevations is more largely responsible for dwarfing on Mount Banahao than is the case on Mount Maquiling. In order to determine the possible relation of temperature to dwarfing on Mount Banahao, temperature indices have been calculated for

altitudes of 1,015, 1,550, and 2,100 meters. That these indices for the different altitudes might be comparable, they have been calculated only for the period from March to November, 1916. The results are given in Table CLXXV. In the first column of

TABLE CLXXV.—*Comparison of temperature indices and heights of trees at different elevations on Mount Banahao.*

Elevation.	Physiological temperature index.	*Pisum*-temperature index.	Physiological temperature index ÷ 1.56.	*Pisum*-temperature index × 1.12.	Height of tallest trees.
Meters.					*Meters.*
1,015	35.3	17.4	22.6	19.5	20
1,550	28.1	16.1	18	18	18
2,100	18.2	13.3	11.7	14.9	14

this table is shown the elevation in meters, and in the second column the temperature indices according to Livingston's physiological system.* These indices were calculated for the different four-week periods and then averaged for the entire time. In the third column are given the *Pisum*-temperature indices. These were calculated from Leitch's paper on the relation of temperature to rates of growth of roots of *Pisum*.† In making these calculations Leitch's curve for rates of growth of *Pisum* for twenty-two and a half hours was drawn on a large scale, and the rates of growth corresponding to the different mean temperatures for four-week periods were taken as the growth indices for these temperatures. The various temperature indices are, of course, simply ratios. In order to have them comparable with the heights of the trees as given in column 6, the physiological temperature indices have been divided by 1.56 and the *Pisum* indices multiplied by 1.12, the results being given in columns 4 and 5. An examination of culumn 5 shows that the ratios for the *Pisum* indices are fairly similar to those for the heights of the trees but that, according to this system, variations of temperature would not be quite sufficient to account for the differences in height. The ratios for the physiological temperature indices are not so similar to the heights of the trees as are those of the *Pisum* indices; but, according to the physiological indices, variations in temperature would be more than

* Livingston, B. E., Physiological temperature indices for the study of plant growth in relation to climatic conditions, *Physiological Researches* (1916), 1, 399–420.

† Leitch, I., Some experiments on the influence of temperature on the rate of growth in Pisum sativum, *Ann. Bot.* (1916), 30, 25–46.

sufficient to account for the differences in height. A consideration of the ratios obtained by these two systems would, therefore, indicate that temperature may be largely responsible for the differences in the heights of the trees at different elevations on Mount Banahao, and that variations in light intensity are not nearly so important in causing variations in height here as on Mount Maquiling. The greater heights of the trees on Mount Banahao than at similar elevations on Mount Maquiling may, therefore, be due largely to a greater light intensity on Mount Banahao, though the more even distribution of rainfall may have a contributing effect.

LIST OF SPECIES MENTIONED IN THE TEXT, WITH AUTHORITIES, LOCAL NAMES, AND FAMILIES

Acacia farnesiana Willd. (aroma). Leguminosae.
Agelaea sp. Connaraceae.
Aglaia diffusa Merr. (salaquin pula). Meliaceae.
Aglaia harmsiana Perk. (malasaging). Meliaceae.
Aglaia iloilo Merr. = *A. argentea* Blume (iloilo). Meliaceae.
Aglaia llanosiana C. DC. (alupag). Meliaceae.
Aglaia sp. (malasaging). Meliaceae.
Aglaomorpha meyeniana Schott. Polypodiaceae.
Ahernia glandulosa Merr. Flacourtiaceae.
Alangium longiflorum Merr. Cornaceae.
Alangium meyeri Merr. (putian). Cornaceae.
Albizzia procera Benth. (acleng parang). Leguminosae.
Allophylus grossedentatus F.-Vill. Sapindaceae.
Alocasia macrorrhiza Schott. Araceae.
Alphonsea arborea Merr. Annonaceae.
Alpinia brevilabris Presl. Zingiberaceae.
Alstonia scholaris R. Br. (dita). Apocynaceae.
Altingia excelsa Noronha. Hamamelidaceae.
Alyxia monilifera Vid. Apocynaceae.
Amoora cumingiana C. DC. Meliaceae.
Amoora sp. Meliaceae.
Anaxagorea luzonensis A. Gray. Annonaceae.
Angiopteris angustifolia Presl. Marattiaceae.
Annona muricata Linn. Annonaceae.
Antidesma ghaesembilla Gaertn. (binayuyu). Euphorbiaceae.
Antidesma pleuricum Tul. Euphorbiaceae.
Ardisia boissieri A. DC. (tagpo). Myrsinaceae.
Ardisia perrottetiana A. DC. Myrsinaceae.
Ardisia serrata Pers. Myrsinaceae.
Areca wendlandiana Scheff. Palmae.
Arenga pinnata Merr. = *A. saccharifera* Labill. (cabo negro). Palmae.
Argostemma wallichii Walp. Rubiaceae.
Artocarpus cumingiana Trec. (anubing). Moraceae.
Artocarpus rubrovenia Warb. (anubing). Moraceae.
Artocarpus woodii Merr. Moraceae.
Asplenium nidus Linn. Polypodiaceae.
Astronia lagunensis Merr. Melastomataceae.
Astronia pulchra Vid. Melastomataceae.
Astronia rolfei Vid. (dungao). Melastomataceae.
Astronia williamsii Merr. (dungao). Melastomataceae.
Bambusa spinosa Roxb. (cauayan). Gramineae.
Barringtonia sp. Lecythidaceae.
Bauhinia malabarica Roxb. (alibangbang). Leguminosae.
Begonia aequata A. Gray. Begoniaceae.
Biophytum sensitivum DC. Oxalidaceae.
Bischofia javanica Bl. (tuai). Euphorbiaceae.

Blumea balsamifera DC. (sambong). Compositae.
Bridelia minutiflora Hook. f. Euphorbiaceae.
Buchanania arborescens Blume (balinghasay). Anacardiaceae.
Bulbophyllum vagans Ames & Rolfe. Orchidaceae.
Calamus spp. (bejuco). Palmae.
Calanthe triplicata Ames. Orchidaceae.
Callicarpa erioclona Schauer (palis). Verbenaceae.
Calyptrocalyx spicatus Blume. Palmae.
Canarium ahernianum Merr. Burseraceae.
Canarium lucidum Perk. Burseraceae.
Canarium luzonicum A. Gray (pili). Burseraceae.
Canarium villosum F.-Vill. (pagsahing). Burseraceae.
Canarium sp. (isan͠gjuac). Burseraceae.
Carica papaya Linn. Caricaceae.
Caryota cumingii Lodd. (pugahan). Palmae.
Caryota sp. (pugahan). Palmae.
Casearia sp. (malatapai). Flacourtiaceae.
Castanospermum sp. Leguminosae.
Ceiba pentandra DC. = *Eriodendron anfractuosum* DC. (kapok). Bombacaceae.
Celtis philippensis Blanco (malaicmo). Ulmaceae.
Ceratostylis senilis Reichb. f. Orchidaceae.
Chisocheton cumingianus C. DC. (salaquing puti). Meliaceae.
Chisocheton pentandrus Merr. (catang macsin or salaquing pula). Meliaceae.
Chisocheton sp. (salaquing pula). Meliaceae.
Chloranthus officinalis Bl. Chloranthaceae.
Christisonia wightii Elm. Orobanchaceae.
Cinchona succirubra Pav. Rubiaceae.
Cinnamomum mercadoi Vid. (calingag). Lauraceae.
Cissus trifolia K. Sch. Vitaceae.
Citrus hystrix DC. (cabuyao). Rutaceae.
Cleidion javanicum Blume. Euphorbiaceae.
Clerodendron quadriloculare Merr. Verbenaceae.
Clethra lancifolia Turcz. Clethraceae.
Coleus multiflorus Benth. Labiatae.
Columbia serratifolia DC. (anilao). Tiliaceae.
Commelina nudiflora Linn. Commelinaceae.
Cordia myxa Linn. (anonang). Boraginaceae.
Corysanthes merrillii Ames. Orchidaceae.
Cotylanthera tenuis Bl. Gentianaceae.
Cratoxylon blancoi Blume. Guttiferae.
Cratoxylon celebicum Blume (guyong-guyong). Guttiferae.
Croton consanguineus Muell. Euphorbiaceae.
Croton leiophyllus Muell. Euphorbiaceae.
Cryptocarya lauriflora Merr. Lauraceae.
Cyathea caudata Copel. Cyatheaceae.
Cyclostemon maquilingensis Merr. (tinaan pantai). Euphorbiaceae.
Cyrtandra incisa Clarke. Gesneriaceae.
Daemonorops spp. (bejuco). Palmae.
Decaspermum paniculatum Lindl. Myrtaceae.
Dendrochilum glumaceum Lindl. Orchidaceae.

Dendrochilum pumilum Reichb. f. Orchidaceae.
Dendrochilum venustulum Pfitz. Orchidaceae.
Desmodium pulchellum Benth. Leguminosae.
Dichrotrichum chorisepalum Clarke. Gesneriaceae.
Dillenia philippinensis Rolfe (catmon). Dilleniaceae.
Dillenia reifferscheidia F.-Vill. (catmon). Dilleniaceae.
Dimorphocalyx longipes Merr. Euphorbiaceae.
Dimorphocalyx luzoniensis Merr. Euphorbiaceae.
Diospyros ahernii Merr. (anang). Ebenaceae.
Diospyros discolor Willd. (camagon). Ebenaceae.
Diospyros pilosanthera Blanco (bolongeta). Ebenaceae.
Diplodiscus paniculatus Turcz. (balobo). Tiliaceae.
Dischidia purpurea Merr. Asclepiadaceae.
Dischidia sp. Asclepiadaceae.
Donax cannaeformis K. Schum. Marantaceae.
Dracontomelum dao Merr. & Rolfe (dao). Anacardiaceae.
Drimys piperita Hook. f. Magnoliaceae.
Drynaria quercifolia J. Sm. Polypodiaceae.
Dysoxylum decandrum Merr. Meliaceae.
Dysoxylum pauciflorum Merr. Meliaceae.
Dysoxylum rubrum Merr. Meliaceae.
Dysoxylum turczaninowii C. DC. Meliaceae.
Elaeocarpus argenteus Merr. Elaeocarpaceae.
Elaeocarpus calomala Merr. Elaeocarpaceae.
Elaphoglossum sp. Polypodiaceae.
Elatostema carinoi W. R. Shaw. Urticaceae.
Elatostema longifolium Wedd. Urticaceae.
Elatostema viridescens Elm. Urticaceae.
Enterolobium saman Benth. Leguminosae.
Epirixanthes cylindrica Blume. Polygalaceae.
Eria sp. Orchidaceae.
Eriobotrya japonica Lindl. Rosaceae.
Eugenia arcuatinervia Merr. Myrtaceae.
Eugenia astronioides C. B. Rob. Myrtaceae.
Eugenia calubcob C. B. Rob. (calubcob). Myrtaceae
Eugenia crassipes C. B. Rob. (calubcob). Myrtaceae.
Eugenia cumini (Linn.) Merr. (duhat). Myrtaceae.
Eugenia longiflora F.-Vill. Myrtaceae.
Eugenia luzonensis Merr. (malaruhat puti). Myrtaceae.
Eugenia mananquil Blanco. Myrtaceae.
Eugenia robertii Merr. Myrtaceae.
Eugenia saligna C. B. Rob. Myrtaceae.
Eugenia similis Merr. (malaruhat). Myrtaceae.
Eugenia sp. (malabayabas). Myrtaceae.
Eulophia exaltata Reichb. f. Orchidaceae.
Euonymus javanica Bl. Celastraceae.
Euonymus viburnifolia Merr. Celastraceae.
Euphoria cinerea Radlk. (alupag). Sapindaceae.
Eurya acuminata DC. Theaceae.
Evodia glabra Blume. Rutaceae.
Evodia semecarpifolia Merr. Rutaceae.
Evodia villamilii Merr. Rutaceae.

Evodia sp. Rutaceae.
Ficus ampelos Burm. f. (malaisis). Moraceae.
Ficus banahaensis Elm. Moraceae.
Ficus barnesii Merr. Moraceae.
Ficus clementis Merr. Moraceae.
Ficus elastica Roxb. Moraceae.
Ficus garciae Elm. Moraceae.
Ficus hauili Blanco (hauili). Moraceae.
Ficus linearifolia Elm. (auymit). Moraceae.
Ficus manilensis Warb. (isis). Moraceae.
Ficus minahassae Miq. (hagimit). Moraceae.
Ficus nervosa Heyne (agusus). Moraceae.
Ficus nota Merr. (tibig). Moraceae.
Ficus paucinervia Merr. (tangisang biauac). Moraceae.
Ficus ribes Reinw. (auymit). Moraceae.
Ficus satterthwaitei Elm. Moraceae.
Ficus ulmifolia Lam. (isis). Moraceae.
Ficus validicaudata Merr. Moraceae.
Ficus variegata Blume (tangisang biauac). Moraceae.
Ficus warburgii Elm. Moraceae.
Flacourtia sp. Flacourtiaceae.
Forrestia philippinensis Merr. Commelinaceae.
Freycinetia robinsonii Merr. Pandanaceae.
Freycinetia williamsii Merr. Pandanaceae.
Freycinetia sp. Pandanaceae.
Galeola hydra Reichb. f. Orchidaceae.
Garcinia binucao Choisy (binucao). Guttiferae.
Garcinia rubra Merr. Guttiferae.
Garcinia venulosa Choisy (gatasan). Guttiferae.
Garcinia spp. Guttiferae.
Glochidion album Boerl. (magna). Euphorbiaceae.
Glochidion lancifolium C. B. Rob. Euphorbiaceae.
Glochidion merrillii C. B. Rob. Euphorbiaceae.
Glochidion philippicum C. B. Rob. Euphorbiaceae.
Glochidion reticulatum Elm. Euphorbiaceae.
Glochidion trichogynum Muell. (bogna). Euphorbiaceae.
Glochidion williamsii C. B. Rob. Euphorbiaceae.
Goniothalamus amuyon Merr. (amuyong). Annonaceae.
Goniothalamus elmeri Merr. Annonaceae.
Grewia stylocarpa Warb. (susumbic). Tiliaceae.
Gymnacranthera paniculata Warb. (tambulao). Myristicaceae.
Hedyotis philippensis Merr. Rubiaceae.
Hemigraphis strigosa F.-Vill. Acanthaceae.
Heterospathe elata Scheff. Palmae.
Hevea brasiliensis Muell. Euphorbiaceae.
Histopteris incisa J. Sm. Polypodiaceae.
Homalanthus alpinus Elm. Euphorbiaceae.
Homalanthus fastuosus Pax. Euphorbiaceae.
Homalanthus populneus Pax (balanti). Euphorbiaceae.
Hopea acuminata Merr. (daliñgdiñgan). Dipterocarpaceae.
Hoya odorata Schltr. Asclepiadaceae.
Hydnophytum sp. Rubiaceae.

Hymenophyllum javanicum Blume. Hymenophyllaceae.
Ilex crenata Thunb. Ilicineae.
Ilex foxworthyi Merr. Aquifoliaceae.
Imperata exaltata Brongn. (cogon). Gramineae.
Ipomoea triloba Linn. Convolvulaceae.
Itea maesaefolia Elm. Saxifragaceae.
Ixora longistipula Merr. Rubiaceae.
Ixora macrophylla Bartl. Rubiaceae.
Knema glomerata Merr. = *K. heterophylla* Warb. (tambalao). Myristicaceae.
Koordersiodendron pinnatum Merr. (amugis). Anacardiaceae.
Laportea subclausa C. B. Rob. (lipa). Urticaceae.
Leea aculeata Blume. Vitaceae.
Leea manillensis Walp. Vitaceae.
Leea philippinensis Merr. Vitaceae.
Leea quadrifida Merr. Vitaceae.
Lepisanthes schizolepis Radlk. Sapindaceae.
Leucaena glauca Benth. (ipil ipil). Leguminosae.
Leucosyke capitellata Wedd. (lagasi). Urticaceae.
Litsea garciae Vid. Lauraceae.
Litsea glutinosa C. B. Rob. (puso puso). Lauraceae.
Litsea luzonica F.-Vill. Lauraceae.
Litsea perrottetii F.-Vill. (marang). Lauraceae.
Livistona sp. (anahau). Palmae.
Lophopetalum toxicum Loher (cala-tumbago). Celastraceae.
Lygodium circinnatum Sw. Schizaeaceae.
Macaranga bicolor Muell.-Arg. (hamindang). Euphorbiaceae.
Macaranga grandifolia Merr. (taquip asin). Euphorbiaceae.
Macaranga tanarius Muell.-Arg. (binunga). Euphorbiaceae.
Macaranga spp. (binunga). Euphorbiaceae.
Machilus philippinensis Merr. Lauraceae.
Mallotus moluccanus Muell.-Arg. (alim). Euphorbiaceae.
Mallotus philippensis Muell.-Arg. (banato). Euphorbiaceae.
Mallotus ricinoides Muell.-Arg. (hinlaumo, alim). Euphorbiaceae.
Mangifera indica Linn. Anacardiaceae.
Mastixia philippinensis Wang. (tapulao). Cornaceae.
Medinilla astronioides Triana. Melastomataceae.
Medinilla multiflora Merr. Melastomataceae.
Medinilla myrtiformis Triana. Melastomataceae.
Medinilla venosa Triana. Melastomataceae.
Melastoma polyanthum Blume. Melastomataceae.
Meliosma macrophylla Merr. Sabiaceae.
Meliosma sylvatica Elm. Sabiaceae.
Melochia umbellata Stapf (labayo). Sterculiaceae.
Memecylon paniculatum Jack (culis). Melastomataceae.
Merremia hastata Hallier f. Convolvulaceae.
Merremia umbellata Hallier f. Convolvulaceae.
Mimosa pudica Linn. Leguminosae.
Mussaenda philippica Rich. (cahoy dalaga). Rubiaceae.
Myristica philippensis Lam. (duguan). Myristicaceae.
Myrmecodia sp. Rubiaceae.
Nauclea junghuhnii Merr. (mambog). Rubiaceae.

Nauclea orientalis Linn.=*Sarcocephalus orientalis* (bancal). Rubiaceae.
Neolitsea villosa Merr. Lauraceae.
Neonauclea calycina Merr. (uisac). Rubiaceae.
Neonauclea media Merr. Rubiaceae.
Neotrewia cumingii Pax & Hoffm. (bato-bato). Euphorbiaceae.
Nepenthes alata Blanco. Nepenthaceae.
Nephelium mutabile Blume (bulala). Sapindaceae.
Nertera depressa Banks & Soland. Rubiaceae.
Octomeles sumatrana Miq. Datiscaceae.
Oleandra colubrina Copel. Polypodiaceae.
Operculina turpethum S. Manso. Convolvulaceae.
Oreocnide trinervis Miq. (malatuba). Urticaceae.
Oreodoxa regia H. B. K. Palmae.
Oroxylum indicum Vent. (pincapincahan). Bignoniaceae.
Osmelia conferta Benth. (malatapai). Flacourtiaceae.
Osmelia philippinensis Benth. Flacourtiaceae.
Palaquium merrillii Dubard. Sapotaceae.
Palaquium philippense C. B. Rob. (palac-palac). Sapotaceae.
Palaquium tenuipetiolatum Merr. (palac-palac or manicnic). Sapotaceae
Pandanus gracilis Blanco. Pandanaceae.
Pandanus luzonensis Merr. Pandanaceae.
Papualthia lanceolata Merr. = *Polyalthia lanceolata* Vidal (lanutan) Annonaceae.
Parashorea malaanonan Merr. = *P. plicata* Brandis (bagtican lauan). Dipterocarpaceae.
Parkia javanica Merr. = *P. timoriana* DC. (cupang). Leguminosae.
Pentacme contorta M. & R. (white lauan). Dipterocarpaceae.
Phacelophrynium sp. Marantaceae.
Phaius sp. Orchidaceae.
Phalaenopsis amabilis Blume. Orchidaceae.
Phreatea. Orchidaceae.
Pinanga barnesii Becc. Palmae.
Pinanga insignis Becc. Palmae.
Pinus insularis Endl. Pinaceae.
Piper longivaginans C. DC. Piperaceae.
Pipturus arborescens C. B. Rob. (dalunot). Urticaceae.
Pisonia umbellifera Seem. (anuling). Nyctaginaceae.
Pithecolobium subacutum Benth. Leguminosae.
Planchonia spectabilis Merr. (lamog). Lecythidaceae.
Plumeria acutifolia Poir. Apocynaceae.
Podocarpus costalis Presl. Taxaceae.
Podocarpus imbricatus Blume. Taxaceae.
Polyalthia cumingiana Merr. Annonaceae.
Polyalthia sp. Annonaceae.
Polypodium sinuatum Wall. Polypodiaceae.
Polyscias nodosa Seem. Araliaceae.
Pometia pinnata Forst. (malugay). Sapindaceae.
Pothos sp. Araceae.
Premna cumingiana Schauer (maguili). Verbenaceae.
Premna odorata Blanco. Verbenaceae.
Psidium guajava Linn. (guava). Myrtaceae.
Psychotria sp. Rubiaceae.

Pteris quadriaurita Retz. Polypodiaceae.
Pterocarpus indicus Willd. (narra). Leguminosae.
Pterocymbium tinctorium Merr. (taluto). Sterculiaceae.
Pterospermum diversifolium Blume (spp.) (bayog). Sterculiaceae.
Pygeum preslii Merr. (uto-uto). Rosaceae.
Quercus robinsonii Merr. (oayan). Fagaceae.
Quercus soleriana Vid. (cataban). Fagaceae.
Radermachera sp. Bignoniaceae.
Rafflesia manillana Teschem. Rafflesiaceae.
Rapanea philippinensis Mez. Myrsinaceae.
Rhododendron kochii Stein. Ericaceae.
Rhododendron quadrasianum Vid. Ericaceae.
Riccia sp. Hepaticae.
Rourea volubilis Merr. Connaraceae.
Rubus fraxinifolius Poir. Rosaceae.
Rungia sp. Acanthaceae.
Saccharum spontaneum L. (talahib). Gramineae.
Sambucus javanica Bl. Caprifoliaceae.
Sapindus saponaria Linn. Sapindaceae.
Saurauia latebracteata Choisy. Dilleniaceae.
Saurauia luzoniensis Merr. Dilleniaceae.
Saurauia whitfordii Merr. Dilleniaceae.
Schefflera sp. Araliaceae.
Schizostachyum diffusum Merr. Gramineae.
Schizostachyum mucronatum Hack. (boho). Gramineae.
Schizostachyum sp. (boho). Gramineae.
Selaginella belangeri Spring. Selaginellaceae.
Selaginella maquiliensis Hieron. Selaginellaceae.
Selaginella pennula Spring. Selaginellaceae.
Semecarpus gigantifolia F.-Vill. (ligas). Anacardiaceae.
Semecarpus philippinensis Engl. (ligas). Anacardiaceae.
Shorea guiso Blume (guijo). Dipterocarpaceae.
Shorea polysperma Merr. (tañgili). Dipterocarpaceae.
Sida javensis Cav. Malvaceae.
Sideroxylon sp. (white nato). Sapotaceae.
Siphonodon celastrineus Griff. Celastraceae.
Sterculia crassiramea Merr. Sterculiaceae.
Sterculia cuneata R. Br. Sterculiaceae.
Sterculia foetida Linn. Sterculiaceae.
Sterculia oblongata R. Br. (malacacao). Sterculiaceae.
Sterculia sp. (lapnit). Sterculiaceae.
Streptocaulon baumii Decne. Asclepiadaceae.
Strobilanthes pluriformis C. B. Clarke. Acanthaceae.
Strombosia philippinensis Rolfe (tamayuan). Olacaceae.
Strongylodon macrobotrys A. Gray. Leguminosae.
Symphorema luzonicum F.-Vill. Verbenaceae.
Symplocos ahernii Brand. Symplocaceae.
Symplocos floridissima Brand. Symplocaceae.
Symplocos luzoniensis Rolfe. Styraceae.
Symplocos merrilliana Brand. Symplocaceae.
Symplocos villarii Vid. Symplocaceae.
Symplocos whitfordii Brand. Styraceae.

Synedrella nodiflora Gaertn. Compositae.
Tabernaemontana pandacaqui Poir. (pandacaqui). Apocynaceae.
Taeniophyllum philippinense Reichb. f. Orchidaceae.
Tectaria sp. Polypodiaceae.
Terminalia edulis Blanco (calumpit). Combretaceae.
Terminalia nitens Presl. Combretaceae.
Terminalia pellucida Presl (calumpit or talisay-gubat). Combretaceae.
Thea montana Merr. Theaceae.
Trema orientalis Blume (anabion). Ulmaceae.
Trichomanes apiifolium Presl. Hymenophyllaceae.
Trichomanes pluma J. Sm. Hymenophyllaceae.
Trichomanes proliferum Bl. Hymenophyllaceae.
Trichosanthes quinquangulata A. Gray (cabalonga). Cucurbitaceae.
Trichosporum philippinenses O. Ktze. Gesneriaceae.
Turpinia pomifera DC. (malabago). Staphyleaceae.
Urandra luzoniensis Merr. (tapulao). Icacinaceae.
Urophyllum banahaense Elm. Rubiaceae.
Utricularia rosulata Benj. Lentibularieae.
Vernonia lancifolia Merr. Compositae.
Voacanga globosa Merr. (bayag-usa). Apocynaceae.
Weinmannia luzoniensis Vid. Cunoniaceae.
Wickstroemia meyeniana Warb. Thymelaeaceae.

GENERAL SUMMARY AND CONCLUSIONS

MOUNT MAQUILING

The vegetation on Mount Maquiling shows a gradation from a tall forest at the base of the mountain to a dwarfed mossy one at the summit.

Between elevations of about 100 and 600 meters there is a tall dipterocarp forest, a type of Schimper's tropical rain forest, characteristic of the lowlands in the Philippines and in many other parts of the Indo-Malayan region. This forest consists of three stories of trees, each composed of different species. The first, or tallest, story is dominated by members of the family Dipterocarpaceae. At middle elevations the forest consists of two stories composed of different tree species. At the top of the mountain there is only one story of trees. These trees are dwarfed and very peculiarly shaped and are thickly covered with mosses and mosslike plants. Mossy forests are frequently found on high mountains in the Philippines and elsewhere in the tropics.

The ground covering in the dipterocarp forest is composed largely of tree seedlings and, at higher elevations, of herbaceous plants.

The epiphytes in the dipterocarp forest are largely phanerogams and are confined chiefly to the largest branches of the tallest trees. At middle elevations epiphytes are more numerous and cryptogams are more conspicuous. Mosses and liverworts may form a thin covering over a considerable portion of the trunks of trees. The greatest development of epiphytes is at the top of the mountain in the mossy forest, where the lower branches and the trunks of the trees are thickly covered with mosses and mosslike plants, in which grow a number of larger plants, including phanerogams. On the smaller branches epiphytes are also numerous, but less so than on the trunks.

The original vegetation around the base of the mountain has been removed, and the land that is not now cultivated is covered with a mixture of grass and second-growth forest composed of small trees.

Humidity is fairly high at all elevations but increases with rising elevations, and at the top of the mountain the atmosphere under the forest is practically saturated most of the time.

The increase in humidity at high elevations is accompanied by an increase in cloudiness and a lower light intensity.

Temperature gradually decreases with rising elevations.

The decrease in temperature and light intensity and the increase in humidity with rising elevations result in a rapid decrease in the rate of evaporation from the base to the summit.

There is a pronounced, though not very severe, dry season in the Maquiling region.

The amount of water in the soil increases with rising elevations, and only at low elevations does it appear to decrease sufficiently during the dry season to have a harmful effect on the vegetation.

Except at the lower elevations the heights of the trees at different altitudes agree very closely with the light-temperature indices—that is, with the product of the light intensity multiplied by temperature indices for growth. This indicates that the decrease in light intensity and temperature, as high elevations are reached, is responsible for the dwarfing of the trees. The heights of the trees at the lower elevations are not so great as would be indicated by the temperature-light indices, but at these elevations the rate of evaporation is evidently sufficiently high at times to be harmful. It is probable that this high rate is responsible for the fact that the trees are not so tall as would be indicated by the temperature-light indices; particularly, as in the lowlands, in regions where there is no pronounced dry season, trees do reach the heights indicated by the temperature-light indices for the base of Mount Maquiling.

The rates of growth of trees at different elevations agree fairly closely with the temperature-light indices.

The increase in epiphytic vegetation, particularly cryptogams, with rising elevations is apparently due to the lower rate of evaporation and the presence of fogs. A thick covering of mosses and mosslike plants seems to be dependent on a practically saturated condition of the atmosphere or on the frequent occurrence of fogs.

The peculiar shapes of the trees in the mossy forest at the top of Mount Maquiling are due largely to the formation of aërial roots, which seem to be favored by the moist conditions obtaining in this forest.

The increase in herbaceous plants with rising elevations is apparently due to an increased moisture content of the soil and a lower rate of evaporation.

On Mount Maquiling are found most of the strikingly bizarre plant genera of the Indo-Malayan region; but such plants are

rare here, as in other places in this region, and have very little effect on the appearance of the vegetation.

MOUNT BANAHAO

On Mount Banahao the dwarfing of the vegetation is much more gradual than on Mount Maquiling. The trees at the summit at an altitude of about 2,100 meters are taller than those at the summit of the east peak of Mount Maquiling at an altitude of 1,050 meters. Variations in temperature on Mount Banahao appear to be sufficient to account for all, or nearly all, of the dwarfing.

As the vegetation on Mount Maquiling and Mount Banahao is typical of many mountains in moist tropical regions it seems not improbable that, when the dwarfing is gradual on such mountains, it is due largely to a decrease in temperature; but where it occurs at lower elevations, as on Mount Maquiling, decrease in light intensity may play an important rôle.

The humidity on Mount Banahao is high at all elevations, but at no altitude is the atmosphere practically saturated most of the time as at the top of Mount Maquiling.

Epiphytic vegetation is not developed at any elevation to the same extent as at the top of Mount Maquiling, although the rainfall at high elevations on Mount Banahao is several times as great as at the top of Mount Maquiling and is more evenly distributed. It would appear, therefore, that heavy rains are not sufficient to produce a dense covering of mosses and mosslike plants, unless they are accompanied by very high humidity or frequent fogs.

APPENDIX

It is usual to give records of temperature and relative humidity according to calendar months. As the data from Mount Maquiling are presented for periods of four weeks rather than for calendar months, it has seemed desirable, for purposes of comparison, to present summary tables of the data obtained from the recording instruments in the more usual form of calendar months. Such tables have been prepared by Mr. Evaristo Adlauan from the writer's original records and are here presented.

TABLE CLXXVI.—*Temperature from October, 1911, to January, 1915, under second-growth trees near the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give degrees centigrade.]

Period.	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
January	29.0	19.4	24.2	26.8	21.7
February	31.9	19.8	24.7	28.1	21.8
March	33.7	20.7	26.8	30.7	23.0
April	34.0	19.6	27.4	31.2	23.5
May	34.6	22.3	27.7	31.8	24.2
June	33.9	21.9	26.9	31.0	23.9
July	32.1	20.9	26.3	29.2	24.2
August	31.0	20.2	26.1	28.6	23.5
September	31.0	20.3	25.9	28.9	23.7
October	32.3	21.0	25.8	28.7	23.6
November	31.1	19.9	25.7	28.1	23.4
December	31.9	19.9	24.8	27.6	22.9
Entire period	34.6	19.4	26.0	29.2	23.3

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TABLE CLXXVII.—*Temperature from January, 1913, to January, 1915, in undergrowth in the dipterocarp forest, Mount Maquiling; altitude, 300 meters.*

[Numbers give degrees centigrade.]

Period.	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
January	24.8	16.6	21.2	22.6	20.1
February	25.6	17.4	21.6	23.2	20.0
March	27.7	18.9	23.0	25.9	21.7
April	29.0	19.4	24.1	26.8	22.1
May	29.4	20.5	24.7	27.4	22.7
June	29.7	20.5	24.6	27.1	22.6
July	28.0	19.4	23.8	25.4	22.5
August	28.0	20.5	23.7	25.6	22.5
September	27.5	19.7	23.3	25.3	21.9
October	27.7	19.4	22.8	24.7	21.5
November	25.9	19.4	22.6	24.0	21.6
December	25.0	19.7	22.0	23.2	21.0
Entire period	29.7	16.6	23.1	25.1	21.7

TABLE CLXXVIII.—*Temperature from August, 1913, to January, 1915, in undergrowth in the dipterocarp forest, Mount Maquiling; altitude, 450 meters.*

[Numbers give degrees centigrade.]

Period.	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
January	23.3	17.2	20.1	21.6	19.3
February	24.5	18.6	20.7	22.4	19.5
March	27.2	19.7	22.9	24.9	21.1
April	27.5	21.1	23.9	25.9	22.4
May	28.6	22.5	25.0	27.0	23.4
June	27.2	20.5	24.1	25.4	22.7
July	26.4	21.4	23.5	24.6	22.6
August	26.7	20.7	23.3	24.7	22.4
September	26.6	20.0	23.2	24.6	22.0
October	27.5	20.0	22.6	24.2	21.7
November	25.6	19.7	22.1	23.6	21.5
December	23.9	19.4	21.6	22.6	20.8
Entire period	28.6	17.2	22.8	24.3	21.6

TABLE CLXXIX.—*Temperature from November, 1912, to January, 1915, in undergrowth in the midmountain forest, Mount Maquiling; altitude, 740 meters.*

[Numbers give degrees centigrade.]

Period.	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
January	22.7	15.6	19.3	20.7	18.6
February	23.3	16.6	19.4	20.9	18.2
March	25.9	18.0	21.3	23.3	19.7
April	26.4	18.3	22.1	24.0	20.6
May	27.5	20.0	23.1	25.1	21.7
June	26.9	18.3	22.9	25.0	21.7
July	26.6	19.4	22.0	23.4	21.3
August	27.2	19.4	21.9	23.5	21.0
September	26.6	19.7	22.2	23.6	21.1
October	26.1	18.9	21.4	23.0	20.5
November	23.9	15.5	20.8	22.1	20.1
December	23.6	16.3	20.0	21.4	19.6
Entire period	27.5	15.5	21.4	23.0	20.3

TABLE CLXXX.—*Temperature from November, 1912, to January, 1915, under the mossy forest at the top of Mount Maquiling; altitude, 1,050 meters.*

[Numbers give degrees centigrade.]

Period.	Maximum.	Minimum.	Mean.	Average of daily—	
				Maxima.	Minima.
January	20.3	12.2	15.9	17.2	15.3
February	20.3	12.8	15.9	17.4	15.4
March	22.2	13.9	17.1	18.8	16.3
April	22.3	13.3	18.2	19.8	17.0
May	23.9	17.0	19.4	21.1	18.1
June	23.9	16.6	19.6	21.6	18.3
July	26.1	14.2	18.7	20.6	19.4
August	21.7	14.8	17.9	19.5	17.1
September	23.7	13.7	18.2	19.8	17.3
October	22.0	15.3	17.4	18.8	16.8
November	21.4	13.8	17.5	18.6	17.1
December	20.3	13.9	17.0	18.0	16.3
Entire period	26.1	12.2	17.7	19.3	17.0

TABLE CLXXXI.—*Relative humidity from October, 1912, to January, 1915, under second-growth trees near the base of Mount Maquiling; altitude, 80 meters.*

[Numbers give percentage of saturation.]

Period.	Maximum.	Minimum.	Mean.	Average of daily— Maxima.	Average of daily— Minima.
January	93.0	56.5	82.9	89.6	71.1
February	93.0	25.0	80.1	89.9	63.1
March	94.0	38.0	76.8	89.9	57.9
April	94.0	43.0	78.9	91.0	60.4
May	95.0	42.0	81.0	92.0	62.8
June	95.0	56.0	83.6	92.1	67.6
July	94.0	61.0	84.3	90.8	72.8
August	94.5	56.0	83.4	90.1	71.5
September	93.0	62.0	83.9	90.6	73.3
October	96.5	59.0	85.7	91.7	76.1
November	93.0	58.5	82.5	90.3	74.2
December	92.5	56.0	84.3	90.4	74.0
Entire period	96.5	25.0	82.3	90.7	68.7

TABLE CLXXXII.—*Relative humidity from May, 1913, to January, 1915, in undergrowth in the dipterocarp forest, Mount Maquiling; altitude, 300 meters.*

[Numbers give percentage of saturation.]

Period.	Maximum.	Minimum.	Mean.
January	97.0	80.0	92.6
February	94.0	47.5	88.0
March	93.0	57.0	85.2
April	92.0	58.5	85.5
May	96.0	58.0	87.8
June	97.0	71.0	90.0
July	96.0	76.0	90.1
August	94.5	75.5	89.2
September	95.0	77.0	91.1
October	96.0	75.0	91.7
November	97.5	82.0	92.9
December	98.0	81.0	93.7
Entire period	98.0	47.5	89.8

TABLE CLXXXIII.—*Relative humidity from July, 1913, to January, 1915, in undergrowth in the dipterocarp forest, Mount Maquiling; altitude, 450 meters.*

[Numbers give percentage of saturation.]

Period.	Maximum.	Minimum.	Mean.
January	97.9	76.0	90.1
February	96.0	45.0	86.7
March	99.0	53.0	84.1
April	98.0	58.0	85.5
May	95.0	56.5	86.0
June	95.0	68.0	88.9
July	94.5	72.0	88.9
August	95.5	72.0	87.7
September	93.5	74.0	88.3
October	93.5	64.0	88.3
November	94.5	78.0	89.9
December	94.5	77.5	90.3
Entire period	99.0	45.0	87.9

TABLE CLXXXIV.—*Relative humidity from June, 1913, to January, 1915, in undergrowth in the midmountain forest, Mount Maquiling; altitude, 740 meters.*

[Numbers give percentage of saturation.]

Period.	Maximum.	Minimum.	Mean.
January	94.5	85.0	91.6
February	95.0	54.5	89.2
March	95.5	55.0	88.9
April	94.5	62.2	88.7
May	96.0	66.1	89.1
June	99.2	73.1	90.7
July	98.0	65.0	91.5
August	98.2	76.0	91.2
September	98.0	67.0	90.4
October	96.0	69.3	91.3
November	98.0	71.6	91.8
December	95.5	80.0	90.9
Entire period	99.2	54.5	90.4

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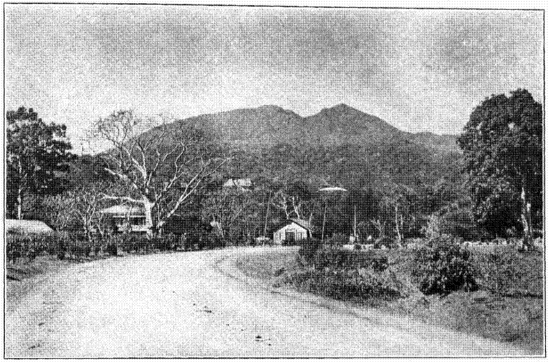

Fig. 1. Mount Maquiling as seen from the College of Agriculture.

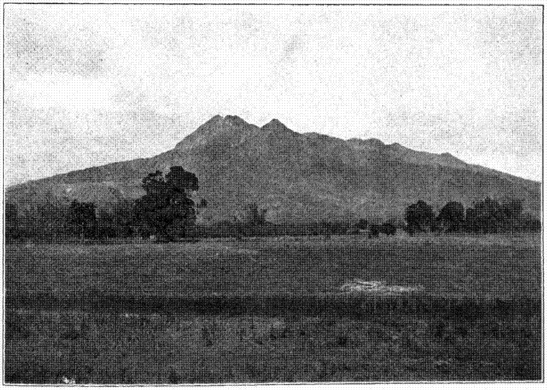

Fig. 2. The southwestern part of Mount Maquiling as seen from Santo Tomas.

PLATE II.

Fig. 1. Section of volcanic tuff from near the base of Mount Maquiling, at an altitude of about 80 meters.

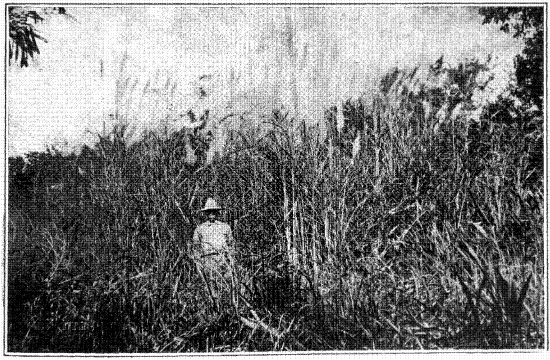

Fig. 2. Saccharum spontaneum.

PLATE III.

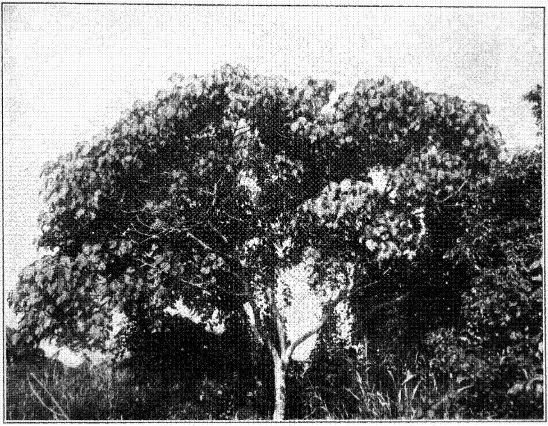

Fig. 1. Macaranga.

Fig. 2. Ficus nota.

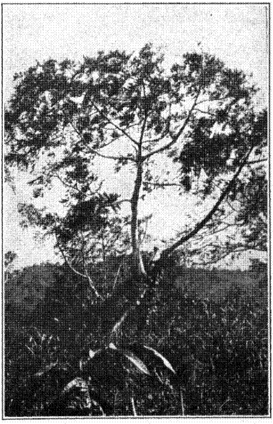

Fig. 3. Trema orientalis.

PLATE IV.

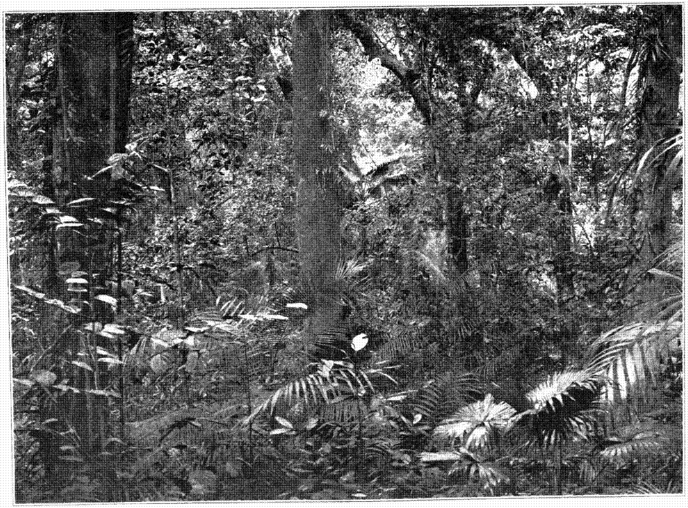

PLATE V. VIEW IN DIPTEROCARP FOREST, MOUNT MAQUILING: ALTITUDE, ABOUT 500 METERS.

Fig. 1. Dipterocarp forest, Mount Maquiling; altitude, about 500 meters.

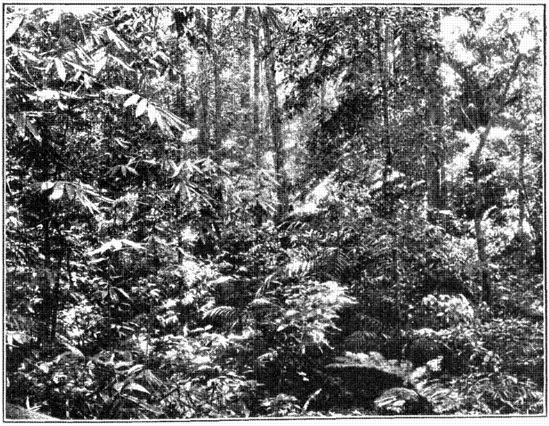

Fig. 2. Dipterocarp forest, Mount Maquiling; altitude, about 300 meters.

PLATE VI.

PLATE VII. VIEW OF DIPTEROCARP FOREST AT THE EDGE OF A CLEARING: ALTITUDE, 450 METERS.

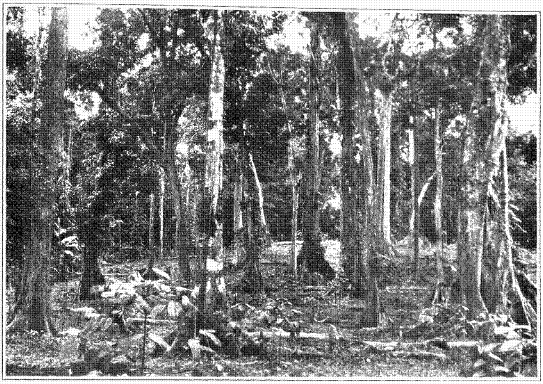

Fig. 1. Dipterocarp forest from which small trees have been removed; altitude, about 300 meters.

Fig. 2. Dipterocarp forest in a ravine on Mount Maquiling; altitude, about 300 meters.

PLATE VIII.

PLATE IX. A GROUP OF LARGE DIPTEROCARPS IN A FOREST IN NORTHERN NEGROS.

Fig. 1. Interior of virgin dipterocarp forest in northern Negros.

Fig. 2. Interior of virgin dipterocarp forest in Bataan Province.

PLATE X.

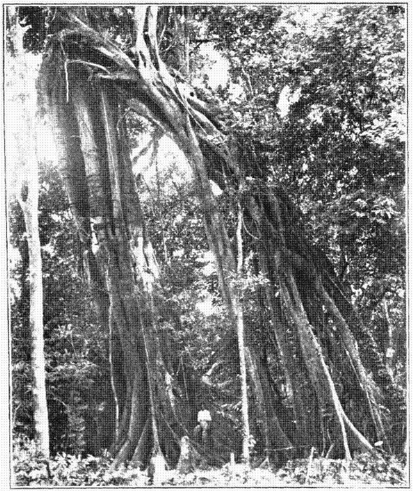

Fig. 1. A strangling fig. Ficus clementis.

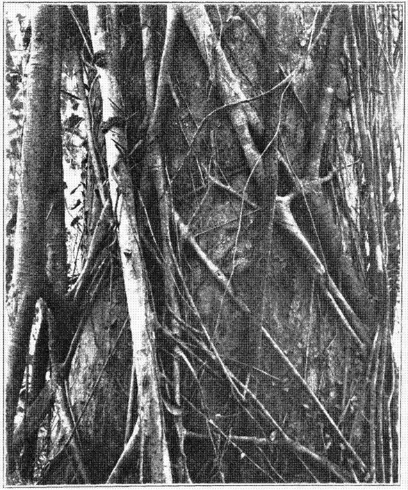

Fig. 2. Anastomosing roots of a strangling fig.

PLATE XI.

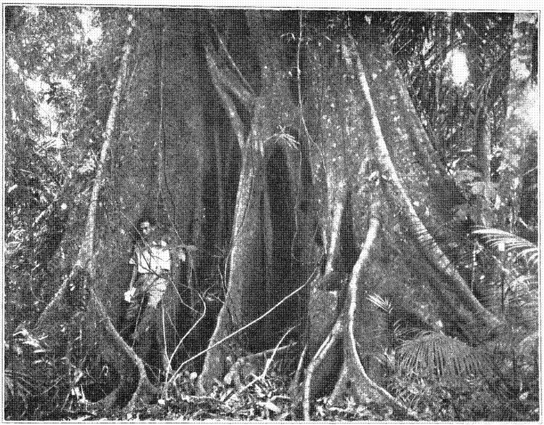

Fig. 1. An old strangling fig.

Fig. 2. Tree with large buttresses.

PLATE XII.

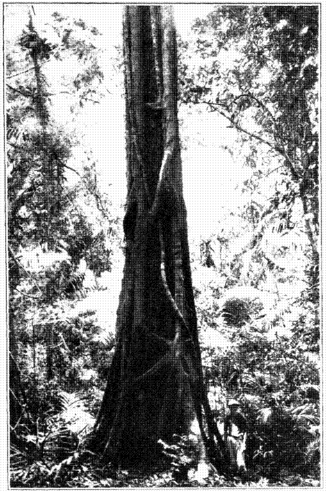

Fig. 1. A strangling fig on a large Parashorea.

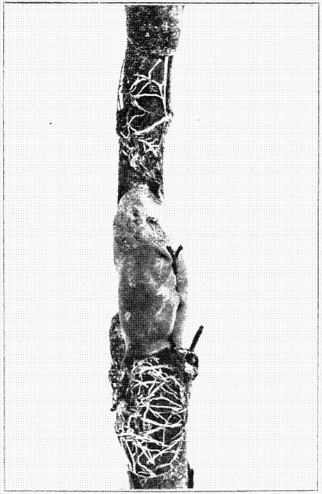

Fig. 2. A myrmecophilous Dischidia.

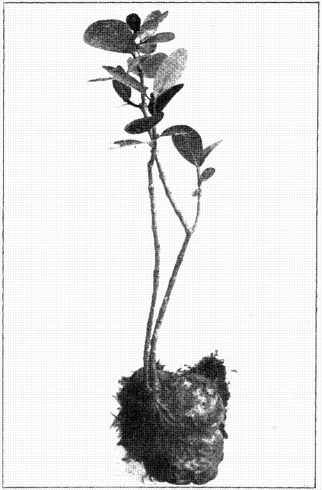

Fig. 3. Hydnophytum.

PLATE XIII.

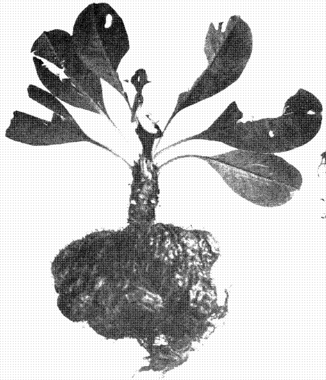
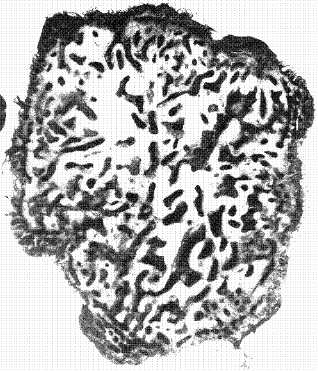
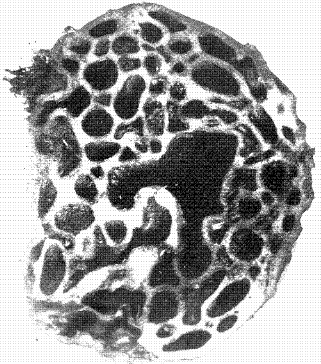

Fig. 1. Myrmecodia.

Fig. 2. Section of base of Myrmecodia, showing cavities.

Fig. 3. Section of base of Hydnophytum, showing cavities.

PLATE XIV.

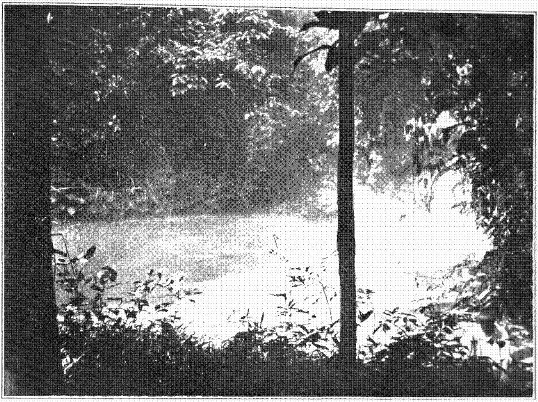

Fig. 1. A mud spring on Mount Maquiling; altitude, about 300 meters.

Fig. 2. Rafflesia manillana.

PLATE XV.

PLATE XVI. MIDMOUNTAIN FOREST: ALTITUDE, ABOUT 700 METERS.

PLATE XVII. UNDERGROWTH IN MIDMOUNTAIN FOREST; ALTITUDE, 740 METERS.

PLATE XVIII. MIDMOUNTAIN FOREST AT 740 METERS.

PLATE XIX. MIDMOUNTAIN FOREST: ALTITUDE, ABOUT 780 METERS.

Fig. 1. Midmountain forest; altitude, about 780 meters.

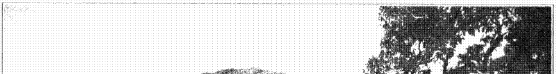

Fig. 2. Exterior view of mossy forest.

PLATE XX.

PLATE XXI. TREE TRUNK, LOWER EDGE OF MOSSY FOREST.

PLATE XXII. AERIAL ROOTS IN MOSSY FOREST.

PLATE XXIII. EPIPHYTES ON BRANCH OF A TREE IN THE MOSSY FOREST.

PLATE XXIV. RHODODENDRON QUADRASIANUM.

PLATE XXV. COVERING OF SELAGINELLA AND FILMY FERNS ON A TREE TRUNK IN THE MOSSY FOREST.

PLATE XXVI. EPIPHYTES ON A TREE TRUNK IN THE MOSSY FOREST.

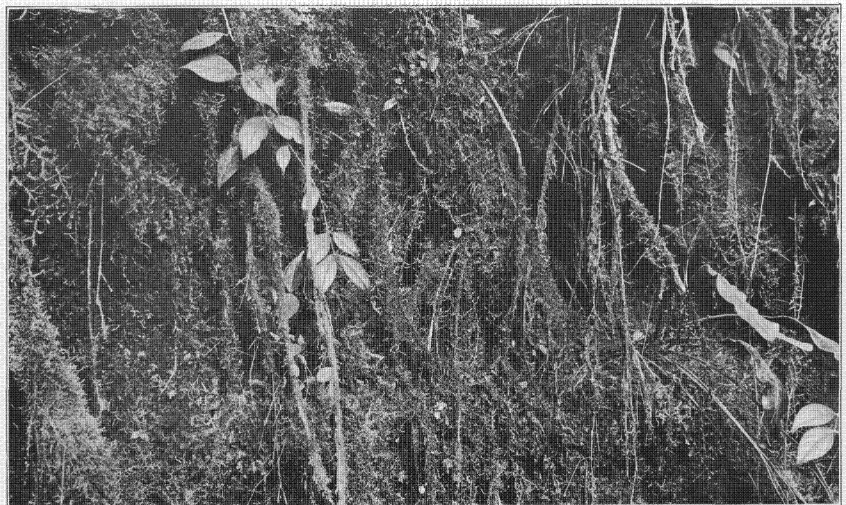

PLATE XXVII. MOSSES AND LIVERWORTS ON AERIAL ROOTS IN THE MOSSY FOREST.

PLATE XXVIII. EPIPHYTIC MOSSLIKE PLANTS AND GROUND COVERING IN THE MOSSY FOREST.

PLATE XXIX. FESTOONS OF EPIPHYTES ON AERIAL ROOTS IN THE MOSSY FOREST.

Fig. 1. Nepenthes alata.

Fig. 2. Freycinetia williamsii.

PLATE XXX.

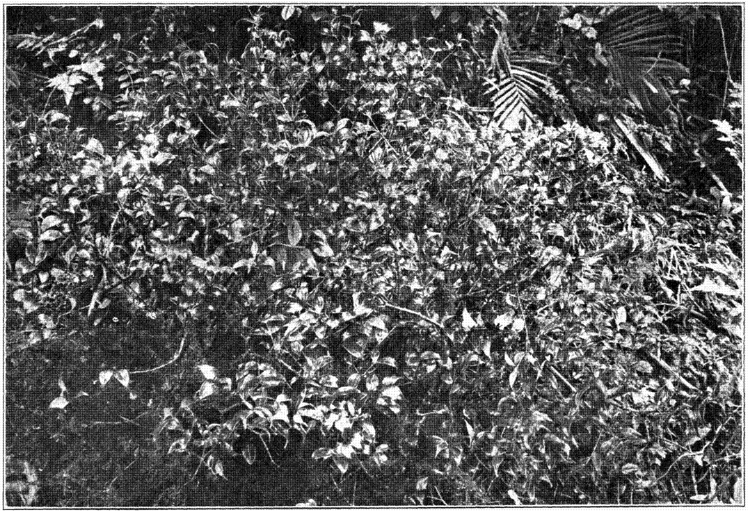

PLATE XXXI. MEDINILLA, GROWING AS AN EPIPHYTE.

PLATE XXXII. MOSSY FOREST NEAR THE TOP OF MOUNT MAQUILING.

PLATE XXXIII. GROUND COVERING OF SELAGINELLA IN THE MOSSY FOREST.

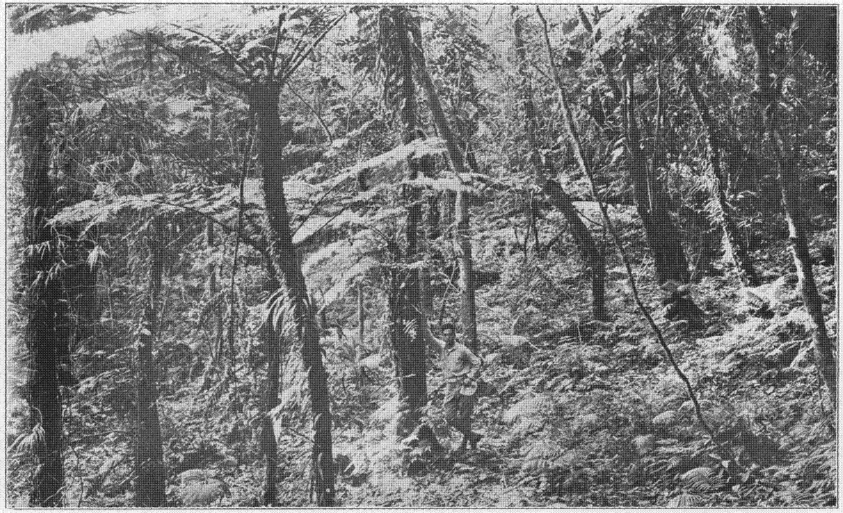

PLATE XXXIV. RAVINE IN THE LOWER PORTION OF THE MOSSY FOREST.

PLATE XXXV. VEGETATION ON A LEVEL AREA NEAR THE LOWER LIMITS OF THE MOSSY FOREST.

PLATE XXXVI. SIDE OF RIDGE NEAR THE RAVINE SHOWN IN PLATE XXXIV.

Fig. 1. Flowers of Melastoma polyanthum.

Fig. 2. Begonia aequata on branch of tree.

PLATE XXXVII.

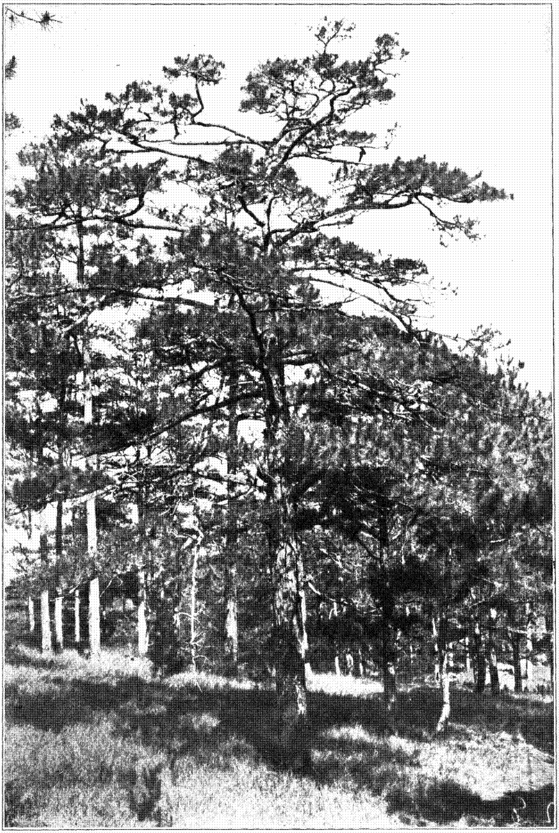

PLATE XXXVIII. PINE FOREST IN BENGUET MOUNTAINS.

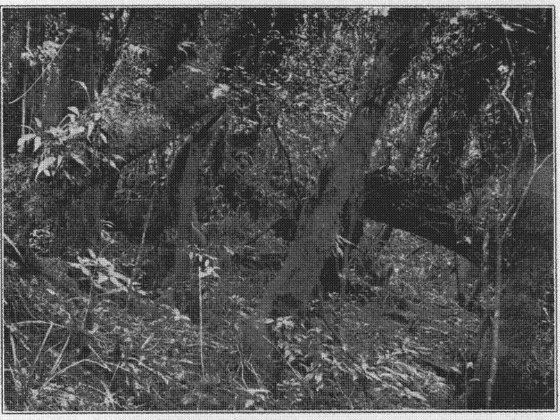

Fig. 1. Podocarpus forest at the top of Mount Banahao.

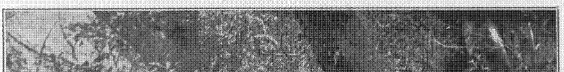

Fig. 2. Podocarpus forest at the top of Mount Banahao.

PLATE XXXIX.

Fig. 1. Forest on Mount Banahao; altitude, 1,000 meters.

Fig. 2. Mossy forest on Mount Banahao; altitude, 1,800 meters.

PLATE XL.

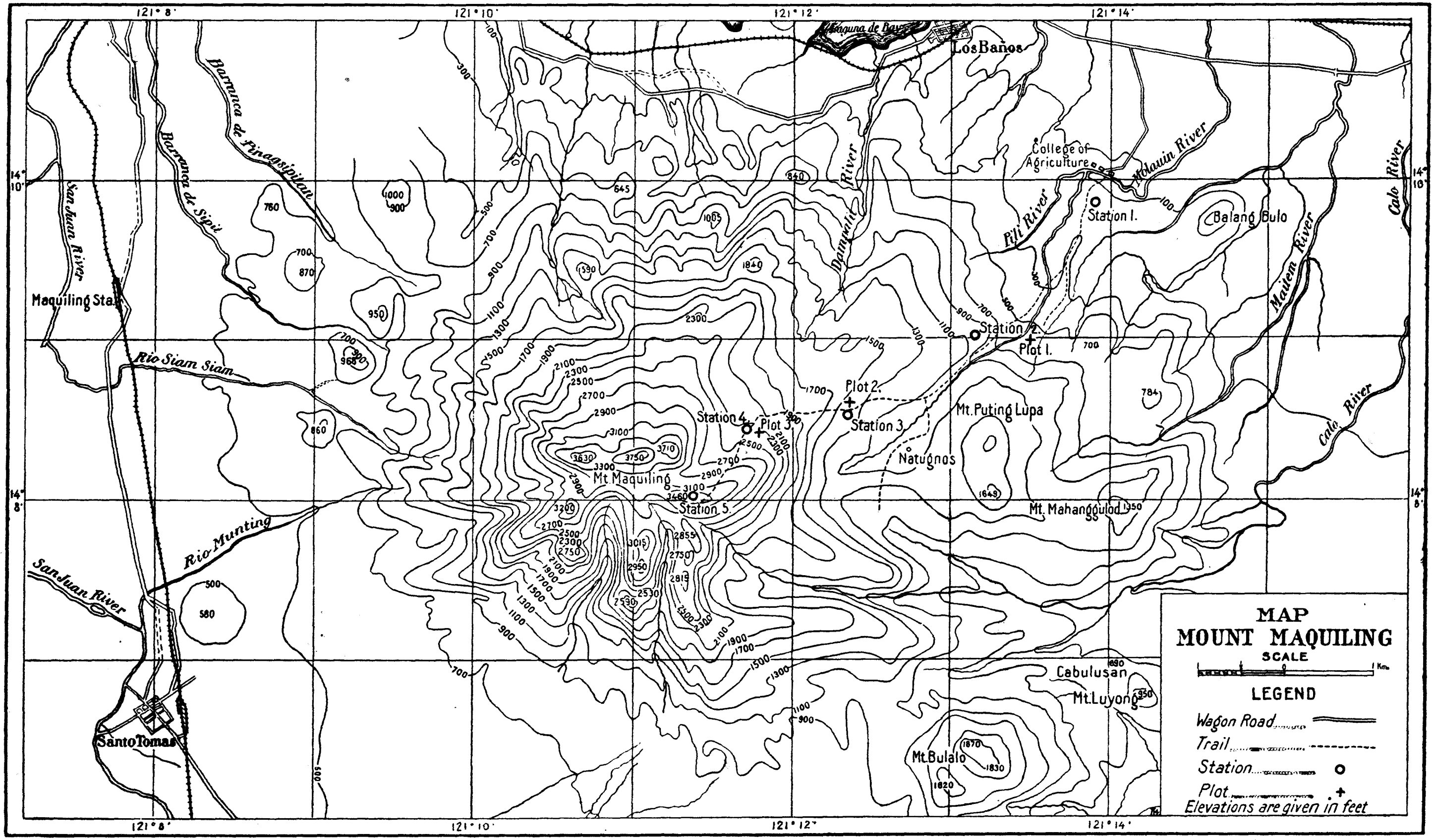

PLATE XLI. MAP OF MOUNT MAQUILING.